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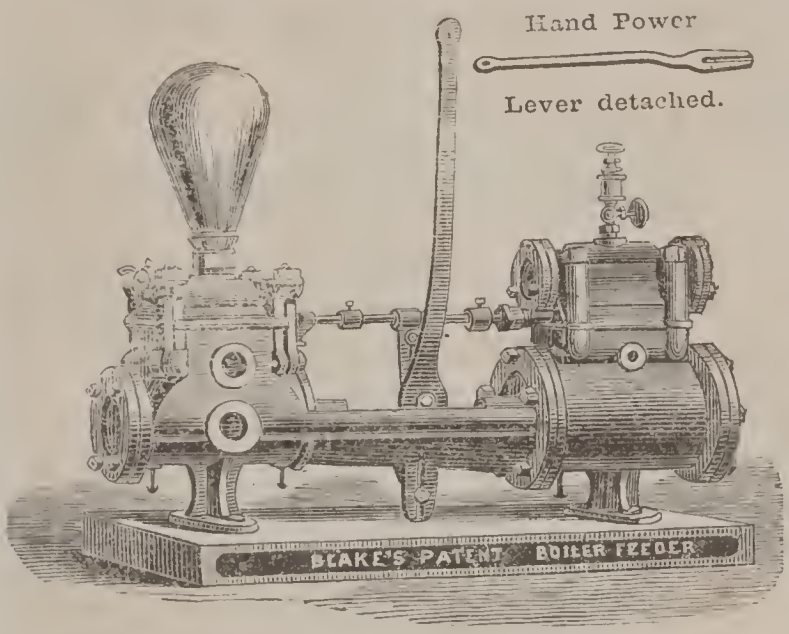

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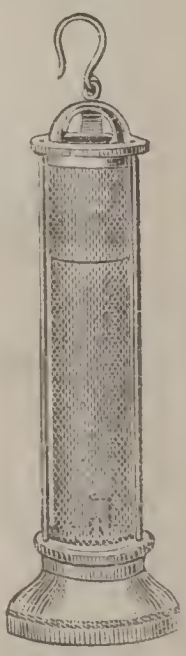

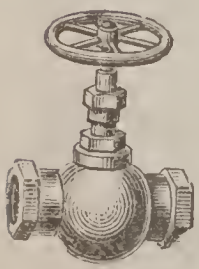

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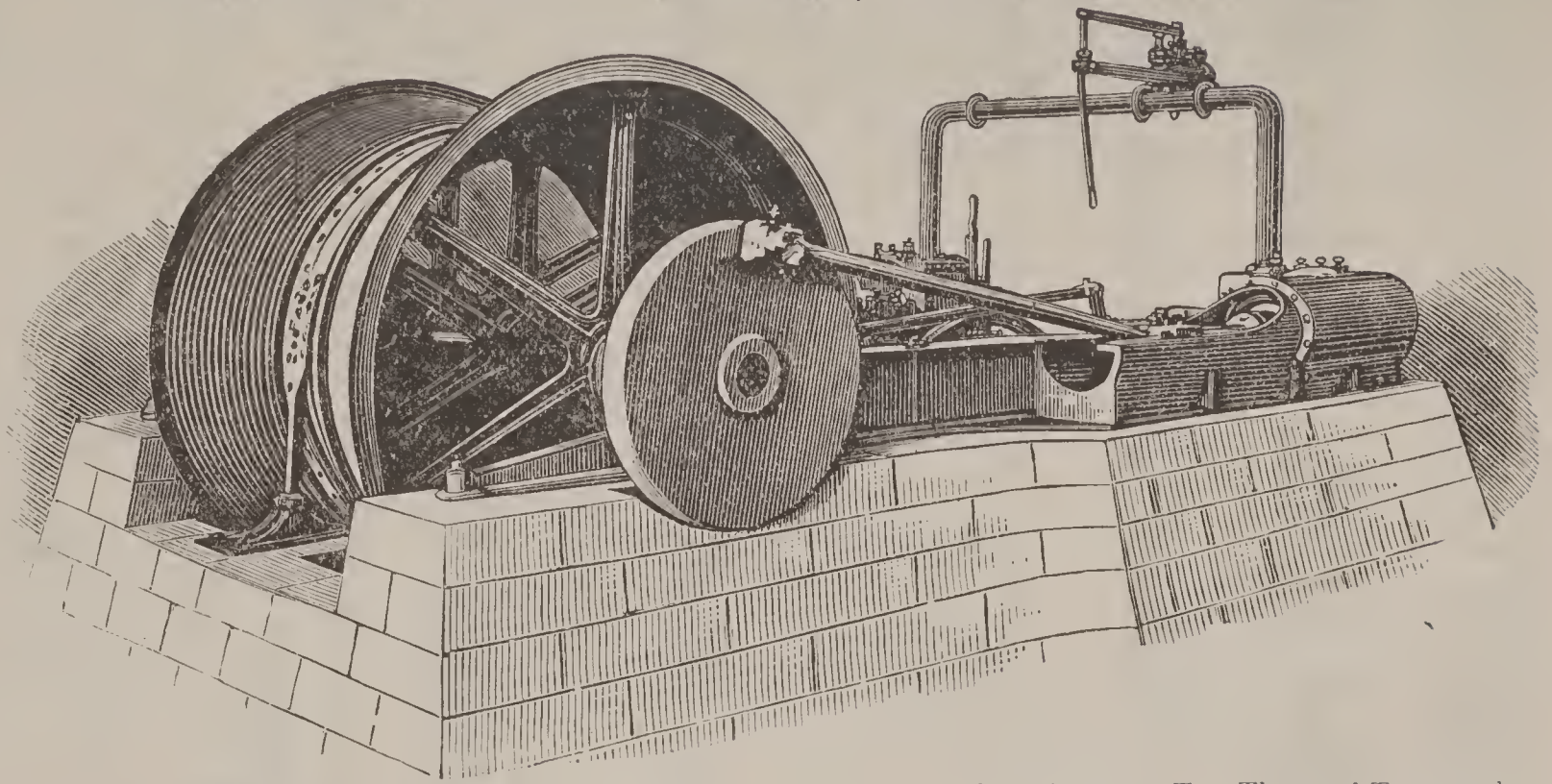

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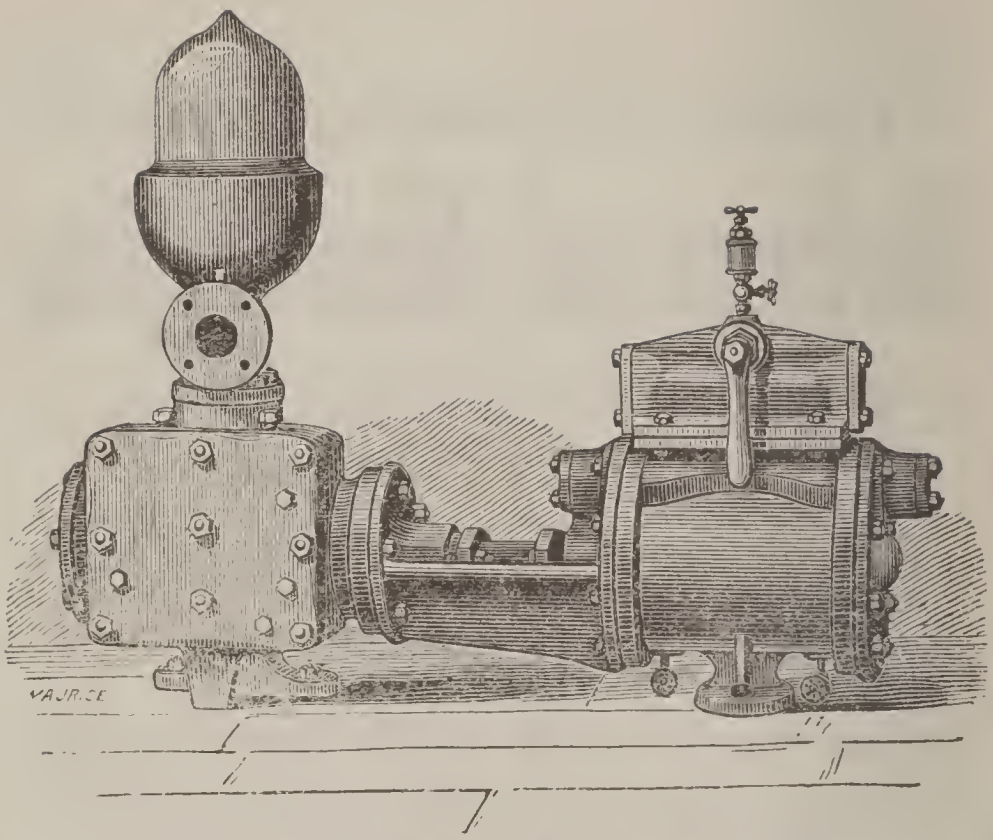

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NEW YORK.

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MINE FOREMAN'S

POCKET BOOK

ALMANAC AND DIARY,

FOR THE YEAR

1881

EDITED BY THOMAS J. FOSTER,

Editor of the Mining Herald.

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(1881)

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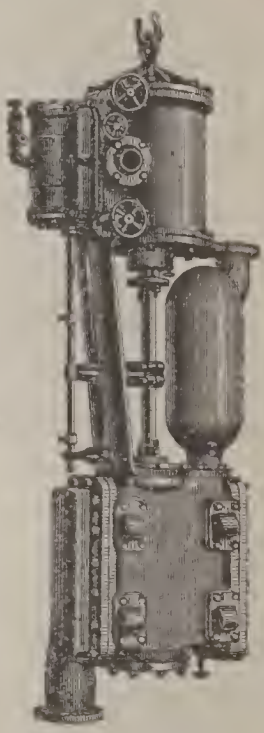

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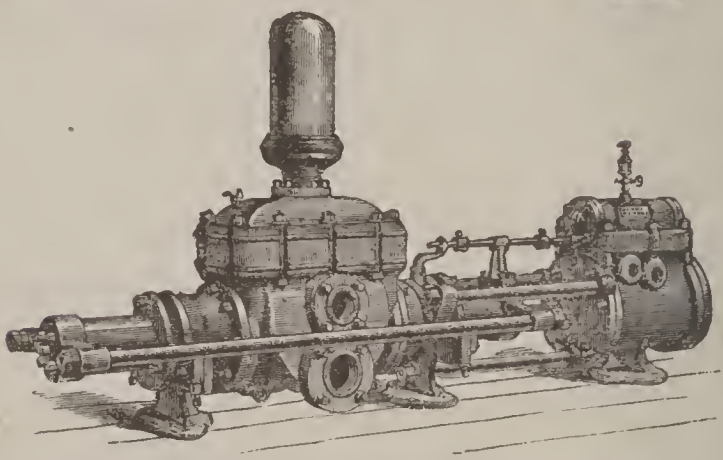

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EDITOR'S ANNOUNCEMENT.

THE MINE FOREMAN'S POCKET BOOK, ALMANAC AND DIARY is an adaptation, in part, of the Colliery Manager's Pocket Book, Almanac and Diary of the distinguished mining engineer and author, Mr. W. Fairley, of London, England. Its publication was suggested by the great scarcity of works on mining among American miners, and it is hoped that it will, in some degree, fill this want and create an interest in technical mine knowledge among our mine owners, mine foremen, and miners generally. It is by no means as complete as it would have been had there been more time for its preparation, but it will prove a useful little book, and will be accepted as a good commencement in a field that has been heretofore unoccupied in this country.

5-2663b

CORRECTION.

In the second line, in the second paragraph, in the article on Fire Damp, on page 141 the word lowest should be *highest.*

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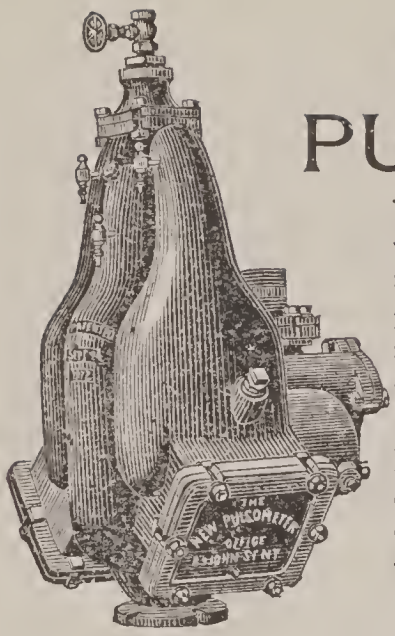

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Office of Waddell & Co., Coal.,
PITTSTON, PA. February 10th, 1881.

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Very truly Yours, WADDELL & Co.

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Office of Coal Run Coal Co.,
STREATER, ILL., November 29th, 1880.

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Your Pump, New Pulsometer No. 7, we have been using six months. It is always in order, and for amount of steam used is more effective than any pump we have ever used.

Yours truly, NELSON PLUMB, Sup't.

McHenry Coal Co.,
McHENRY, OHIO Co., KY., February 23d, 1880.

Pulsometer Steam Pump Co.:

We have been using one of your No. 7 New Pulsometer Pumps in our mines for about three years. It throws more water than any pump I ever saw, and I heartily recommend it to any one who wants a good pump, with no machinery to get out of repair. Yours truly, W. G. DUNCAN, Sup't.

Send for book giving full description, reduced prices, and many letters of commendation from leading manufacturers and others throughout the country who are using them.

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Office, No. 83 John St., New York City.

1881

YEAR 6594, the Julian Period.
2634, the foundation of Rome, according to Varron.
7389-90, of the World, Constantinopolitan account.
7373, of the World, Alexandrian account.
5642, of the Jewish Era, commences on September 24th, 1881.
1299, of the Mahommedan Era, commences on November 23d, 1881.

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THE FOUR SEASONS.

Spring begins,	March 20th,	6.24 a. m.
Summer begins,	June 21st,	2.32 a. m.
Autumn begins,	Sept. 22d,	4.54 p. m.
Winter begins,	Dec. 21st,	11.04 a. m.

LEGAL HOLIDAYS.

New Year's Day,	January 1
Washington's Birthday,	February 22
Decoration Day,	May 30
Independence Day,	July 4

General Election, first Tuesday after first Monday in Nov'r.
Thanksgiving, . . . Usually a Thursday in November.
Christmas, December 25

MOVEABLE FEASTS, ETC.

Septuagesima,	Feb. 13	Easter,	Apr. 17
Sexagesima,	Feb. 20	Ascension,	May 26
Ash Wednesday,	Mar. 2	Whit Sunday,	June 5
First Sun. in Lent,	Mar. 6	Trinity,	June 12
Palm Sunday,	Apr. 10	Advent,	Nov. 27
Good Friday,	Apr. 15		

EMBER DAYS.

1. Wednesday, Friday and Saturday after first Sunday in Lent, March 9th, 11th, 12th.
2. Wednesday, Friday and Saturday after Pentecost, June 8th, 10th, 11th.
3. Wednesday, Friday and Saturday after September 14th, 21st, 23d, 24th.
4. Wednesday, Friday and Saturday after third Sunday in Advent, December 14th, 16th, 18th.

PLANETS BRIGHTEST.

Mercury, Feb. 23d, after sunset. April 7th, before sunrise. June 19th, after sunset. Aug. 5th, before sunrise. Oct. 16th, after sunset. Nov. 23d, before sunrise.

Venus, June 9th. Mars, Dec. 26th. Jupiter, Nov. 13th. Saturn, Oct. 31st.

ECLIPSES.

This year will have four Eclipses, two of the Sun and two of the Moon, and a Transit of Mercury.

I. A Partial Eclipse of the Sun May 27th, visible to the northwestern part of the United States just before sunset.

II. A Total Eclipse of the Moon June 11th and 12th, visible as follows:

Visible at	Begins	Totality.			Ends
		Begins	Middle	Ends	
		A. M.	A. M.	A. M.	A. M.
Boston	12th, 0.26 A. M.	1.29	1.56	2.51	3.52
New York	" 0.14 "	1.17	1.44	2.39	3.40
Philadelphia	" 0.10 "	1.13	1.40	2.35	3.36
Washington	" 0.22 "	1.05	1.48	2.27	3.28
Buffalo	11th, 11.55 P. M.	0.58	1.41	2.20	3.21
Charlestown	" 11.50 "	0.53	1.36	2.15	3.16
St. Louis	" 11.09 "	0.12	0.55	1.34	2.35
Chicago	" 11.20 "	0.23	1.06	1.45	2.46

III. An Annular Eclipse of the Sun Nov. 21st, visible in the Southern Hemisphere.

IV. A Partial Eclipse of the Moon, invisible in the United States.

V. A Transit of Mercury, Nov. 7, visible to the United States at the following time, Washington mean time:

Ingress—Exterior contact, 7d. 5h. 7m. 54s. Interior contact, 7d. 5h. 9m. 37s.

Least distance of centres—231°.1. 7d. 7h. 48m. 20s.

Egress—Interior contact, 7d. 10h. 27m. 2s. Exterior contact, 7d. 10h. 23m. 10s.

PHASES OF THE MOON—PHILADELPHIA.

MAY.

	D.	H.	M.	
First Quarter	6	5	43	a. m.
Full Moon	13	5	23	p. m.
Last Quarter	20	10	7	a. m.
New Moon	27	6	35	p. m.

JUNE.

First Quarter	4	10	19	p. m.
Full Moon	12	1	56	a. m.
Last Quarter	18	4	18	p. m.
New Moon	26	9	3	a. m.

JULY.

First Quarter	4	0	16	p. m.
Full Moon	11	9	13	a. m.
Last Quarter	18	0	33	a. m.
New Moon	26	0	18	a. m.

AUGUST.

First Quarter	2	11	42	p. m.
Full Moon	9	4	6	p. m.
Last Quarter	16	11	57	a. m.
New Moon	24	3	45	p. m.

SEPTEMBER.

	D.	H.	M.	
First Quarter	1	9	2	a. m.
Full Moon	7	11	39	p. m.
Last Quarter	15	3	1	a. m.
New Moon	23	6	54	a. m.
First Quarter	30	4	48	p. m.

OCTOBER.

Full Moon	7	8	59	a. m.
Last Quarter	14	9	25	p. m.
New Moon	22	9	31	p. m.
First Quarter	29	11	47	p. m.

NOVEMBER.

Full Moon	5	9	3	p. m.
Last Quarter	13	6	1	p. m.
New Moon	21	11	21	a. m.
First Quarter	28	7	1	a. m.

DECEMBER.

Full Moon	5	0	13	p. m.
Last Quarter	13	3	4	p. m.
New Moon	21	0	7	a. m.
First Quarter	27	3	41	p. m.

Sun rises { 1st, 4h 58m. 15th, 4h 42m.

MAY.

Sun sets { 1st, 6h 56m. 15th, 7h 10m.

1	S.	**2d Sunday after Easter.**
2	M.	Hudson Bay Company established, 1670.
3	Tu.	Bacon disgraced, 1626.
4	W.	Dr. Livingstone died, 1873.
5	Th.	Napoleon Bonaparte died, 1821.
6	F.	Fire at Audenried Shaft, 1879 (6 lives lost).
7	S.	Explosion of gas, Wadesville Colliery, 1877 (7 killed).
8	S.	**3d Sunday after Easter.**
9	M.	Stonewall Jackson killed, 1863.
10	Tu.	Centennial (International) opened at Philad'a, 1876.
11	W.	Sir J. F. W. Herschel died, 1871.
12	Th.	Charleston surrendered, 1780.
13	F.	First settlement of Jamestown, Va., 1607.
14	S.	Grattan died, 1820.
15	S.	**4th Sunday after Easter.**
16	M.	Rapin died, 1725.
17	Tu.	Grant sails to Europe, 1877.
18	W.	Napoleon I. Emperor, 1801.
19	Th.	Peace with Mexico, 1848.
20	F.	Christopher Columbus died, 1506.
21	S.	St. Helena discovered, 1502.
22	S.	**Rogation Sunday.**
23	M.	Battle of Ramillies, 1706.
24	Tu.	Nicholas I. crowned, 1829.
25	W.	Emerson born, 1803.
26	Th.	*Ascension Day.—Holy Thursday.*
27	F.	West Pittston shaft disaster, 1871 (20 killed).
28	S.	Sir Humphrey Davy died, 1829.
29	S.	**Sunday after Ascension.**
30	M.	*Decoration Day—Soldiers' Graves.*
31	Tu.	Battle of St. Lazaro, 1746.

Sun rises { 1st, 4h 30m. / 15th, 4h 28m.

JUNE.

Sun sets { 1st, 7h 25m. / 15th, 7h 33m.

1	W.	Port Boston closed, 1774.
2	Th.	Explosion at Phoenix Park No. 2, 1876 (4 killed).
3	F.	Walworth shot, 1873.
4	S.	Mexican War declared, 1845.
5	**S.**	**Whit Sunday.**
6	M.	Battle Stony Creek, 1813.
7	Tu.	Explosion at Wood Pit, Haydock, Eng., '80 (180 killed)
8	W.	Black Prince died, 1376.
9	Th.	George Stephenson born, 1781.
10	F.	Ferndale Coll'y Expl'n, Eng., 1869 (80 killed).—Ten men killed by an explosion of gas at Henry Clay Coll'y, '73.
11	S.	Sir John Franklin died, 1847.
12	**S.**	**Trinity Sunday.**
13	M.	Berlin Congress, 1878.
14	Tu.	United States flag, 13 stars and stripes, adopted, 1777
15	W.	Luther excommunicated, 1520.
16	Th.	*Corpus Christi.*
17	F.	Battle of Bunker Hill, 1775.
18	S.	Battle Chalgrove, 1643.
19	**S.**	**1st Sunday after Trinity.**
20	M.	Augsburg Diet met, 1530.
21	Tu.	Summer begins.
22	W.	Haydon died, 1846.
23	Th.	Explosion in Lubec, 1792.
24	F.	Newfoundland discovered by Cabot.
25	S.	Napoleon's Farewell, 1815.
26	**S.**	**2d Sunday after Trinity.**
27	M.	Joseph Smith shot, 1844.
28	Tu.	Queen Victoria crowned, 1838.
29	W.	Earthquake in Italy, 1877.
30	Th.	William Roscoe died, 1831.

Sun rises { 1st, 4h 32m. 15th, 4h 42m.

JULY.

Sun sets { 1st, 7h 35m. 15th, 7h 30m.

1	F.	Charlie Ross kidnapped, 1874.
2	S.	Explosion, High Blantyre Col'ry, Scot., '79 (26 killed).
3	**S.**	Fire in Atwater Mine, Portage Co., O., '77 (10 killed).
4	M.	***Independence Day.***
5	Tu.	Seven men suffocated by gases from locomotive used in Brookfield Mine, Trumbull Co., O., 1877.
6	W.	Battle of Chippewa, 1814.
7	Th.	Robert Dale Owen died, 1877.
8	F.	Port Hudson surrendered, 1863.
9	S.	Gen'l Braddock's defeat on the Monongahela, 1755.
10	**S.**	**4th Sunday after Trinity.**
11	M.	George Attwood, mathematician, died, 1807.
12	Tu.	Morgan's Raid, 1863.
13	W.	Treaty of Berlin signed, 1878.
14	Th.	Bastile destroyed, 1789.
15	F.	Flight of Mahomet, 622.
16	S.	Stony Point taken, 1779.
17	**S.**	**Fifth Sunday after Trinity.**
18	M.	Papal Infallibility, 1870.
19	Tu.	Bodleian Library founded, 1610.
20	W.	Spanish Armada defeated, 1588.
21	Th.	Robert Burns died, aged 37, 1796.
22	F.	Cromwell invaded Scotland, 1650.
23	S.	Printing invented, 1440.
24	**S.**	**6th Sunday after Trinity.**
25	M.	Stephenson's first locomotive tested, 1814.
26	Tu.	Atlantic cable laid, 1866.
27	W.	Death of Messrs. Wasley, Wilman & Reese at Kehley Run Colliery, 1880.
28	Th.	Canal between Forth and Clyde opened, 1792.
29	F.	Wilberforce died, 1833.
30	S.	Chambersburg burned, 1864.
31	**S.**	**7th Sunday after Trinity.**

Sun rises { 1st, 4h 57m. / 15th, 5h 10m.

AUGUST.

Sun sets { 1st, 7h 16 m. / 15th, 6h 58m.

1	M.	George I. crowned, 1714.
2	Tu.	Battle of Sedan, 1870.
3	W.	Arkwright died, 1792.
4	Th.	Iowa admitted, 1846.
5	F.	Experiments to ascertain the density of the earth commenced by Prof. Airy, at Harton Colliery, Eng., 1854.
6	S.	Battle Hanging Rock, 1780.
7	**S.**	**8th Sunday after Trinity.**
8	M.	Riots in Kilkenny, 1858.
9	Tu.	First Treaty Wash. (Ashburton & Webster) signed '42.
10	W.	Battle Wilson's Creek, 1861.
11	Th.	Davis' Straits discovered, 1585.
12	F.	George IV. born, 1792.
13	S.	Lavoisier born, 1743.
14	**S.**	**9th Sunday after Trinity.**
15	M.	Sir Walter Scott born, 1769.
16	Tu.	Gas first introduced in London, 1807.
17	W.	Frederick the Great died, 1786.
18	Th.	Corner stone Capitol laid, 1793.
19	F.	Frigate Guerriere capt'd by the Constitution, 1812.
20	S.	Explosion at Garswood Colliery, 1867.
21	**S.**	**10th Sunday after Trinity.**
22	M.	Battle of Bosworth Field, 1485.
23	Tu.	Alex. Wilson died, 1813.
24	W.	Washington city taken, 1814.
25	Th.	Michael Faraday died, 1867.
26	F.	Prince Albert born, 1819.
27	S.	New Amsterdam surrendered, 1664.
28	**S.**	**11th Sunday after Trinity.**
29	M.	Norway and Denmark united, 1450.
30	Tu.	William Penn died, 1718.
31	W.	John Bunyan died, 1688.

Sun rises { 1st, 5h 27m. 15th, 5h 41m.

SEPTEMBER.

Sun sets { 1st, 6h 32m. 15th, 6h 9m.

1	Th.	Lopez garroted, 1851.
2	F.	Napoleon III. surrendered, 1870.
3	S.	Definitive Treaty of Peace with Great Britain, 1783.
4	**S.**	**12th Sunday after Trinity.**
5	M.	Continental Congress, 1774.
6	Tu.	Explosion at Moss Col'ry, Wigan, Eng., '71 (70 killed).
7	W.	Battle of Belmont, 1861.
8	Th.	Explosion at Seaham Pit, 1880 (140 lives lost).
9	F.	Sebastapol taken, 1855.
10	S.	Com. Perry's victory, Battle of Lake Erie, 1813.
11	**S.**	**13th Sunday after Trinity.**
12	M.	Guizot died, 1874.
13	Tu.	Philip II. died, 1518.
14	W.	J. Fenimore Cooper died, 1851.
15	Th.	J. Fenimore Cooper born, 1789.
16	F.	Terrible Disaster at Avondale, 1869 (100 lives lost).
17	S.	Battle of Antietam, 1862.
18	**S.**	**14th Sunday after Trinity.**
19	M.	Battle of Iuka, 1862.
20	Tu.	Second exp. at Moss Pitts, Wigan, Eng., '71 (5 killed).
21	W.	Sir Walter Scott died, aged 61, 1832.
22	Th.	Mormonism founded, 1827.
23	F.	Russian Fleet sunk, 1854.
24	S.	Don Pedro died, 1834.
25	**S.**	**15th Sunday after Trinity.**
26	M.	Battle Pilot Knob, 1864.
27	Tu.	Alva takes Rome, 1557.
28	W.	Strasbourg captured, 1870.
29	Th.	William the Conqueror landed in England, 1066.
30	F.	Treaty concluded bet'n United States and France, 1800.

Sun rises { 1st, 5h 56m. 15th, 6h 12m.

OCTOBER.

Sun sets { 1st, 5h 42m. 15th, 5h 20m.

1	S.	Battle of Lowositz, 1756.
2	**S.**	Explosion at Otto Red Ash Colliery, 1871 (5 killed).
3	M.	Black Hawk died, 1838.
4	Tu.	Selkirk exiled, 1704.
5	W.	Cornwallis died, 1805.
6	Th.	Alex. Murray died, 1821.
7	F.	Rope broke at Boston Run Colliery, 1876 (4 killed).
8	S.	Explosion at Prospect Colliery, 1878 (4 killed).
9	**S.**	**17th Sunday after Trinity.**
10	M.	First overland mail, 1858.
11	Tu.	Dr. Kane returns, 1855.
12	W.	Columbus discovered America, San Salvador, 1492.
13	Th.	N. Y. Banks suspend, 1857.
14	F.	William Penn born, 1644.
15	S.	Napoleon Bonaparte born, 1769.
16	**S.**	**18th Sunday after Trinity.**
17	M.	Battle of Saratoga, 1777.
18	Tu.	St. Alban's raid, 1864.
19	W.	Surrender of Cornwallis at Yorktown, 1781.
20	Th.	George I. crowned, 1714.
21	F.	Colliery explosion at Blantyre, near Glasgow, 1877.
22	S.	Revocation of the edict of Nantes, 1685.
23	**S.**	**19th Sunday after Trinity.**
24	M.	Spain cedes Florida, 1820.
25	Tu.	Davy announced discovery of Safety Lamp, 1815.
26	W.	Hogarth died, 1764.
27	Th.	Captain Cook born, 1728.
28	F.	Tammany Ring tried, 1871.
29	S.	Stokes sentenced, 1873.
30	**S.**	**20th Sunday after Trinity.**
31	M.	***Hallowmas Eve.***

Sun rises { 1st, 6h 31m. 15th, 6h 47m.

NOVEMBER.

Sun sets { 1st, 4h 56m. 15th, 4h, 42m.

1	Tu.	Earthquake at Lisbon, 1755.
2	W.	Explosion at Mill Creek Colliery, 1879 (5 killed).
3	Th.	Great Eastern launched, 1857.
4	F.	George Peabody died, 1869.
5	S.	Gunpowder plot.
6	**S.**	**21st Sunday after Trinity.**
7	M.	First newspaper printed, 1663.
8	Tu.	New York and Erie Railroad begun, 1835.
9	W.	Great fire at Boston, 1872; loss, $73,600,000.
10	Th.	Oliver Goldsmith born, 1728.
11	F.	***Martinmas.***
12	S.	French siege Vienna, 1805.
13	**S.**	**22d Sunday after Trinity.**
14	M.	Sir Charles Lyell born, 1797.
15	Tu.	Explosion at Low Hall Col'ry, Eng., '69 (26 killed)
16	W.	Battle of Lutzen, 1632.
17	Th.	Suez canal opened, 1869.
18	F.	Powder explosion, Locust Dale Col'ry, '75 (4 killed)
19	S.	Jay's Treaty with Great Britain signed, 1794.
20	**S.**	**23d Sunday after Trinity.**
21	M.	Berlin Decree issued, 1806.
22	Tu.	Dugdale Stewart, philosopher, born, 1753.
23	W.	Elbridge Gerry died, 1814.
24	Th.	Stephenson's third Safety Lamp tested, 1815.
25	F.	Poland ends, 1795.
26	S.	Marshal Soult died, 1857.
27	**S.**	**1st Sunday in Advent.**
28	M.	Washington Irving died, 1859.
29	Tu.	Savannah taken, 1778.
30	W.	***St. Andrew's Day.***

Sun rises { 1st, 7h, 5m. / 15th, 7h 18m.

DECEMBER.

Sun sets { 1st, 4h 32m. / 15th, 4h 34m.

1	Th.	Princess of Wales born, 1844.
2	F.	Battle of Austerlitz, 1805.
3	S.	Illinois admitted, 1818.
4	S.	**2d Sunday in Advent.**
5	M.	Mozart died, 1791.
6	Tu.	Emperor William born, 1792.
7	W.	Sydney beheaded, 1683.
8	Th.	Explosion Edmund's Main Col'ry, Eng. 1862 (54 k'd)
9	F.	Father Matthew died, 1858.
10	S.	Death of Leopold I., 1865.
11	S.	Plague in London, 1625.
12	M.	Sir M. J. Brunel died, 1849.
13	Tu.	Talk-'o-th'-Hill Explosion, Eng., 1866 (91 killed).
14	W.	Prince Albert died, 1861.
15	Th.	Louis J. Agassiz died, 1873.
16	F.	Fredericksburg evacuated by Union Army, 1863.
17	S.	Milan Decree published, 1807.
18	S.	Humphrey Davy born, 1778.
19	M.	Henry II. crowned, 1154.
20	Tu.	Sherman entered Savannah, 1864.
21	W.	Powder Exp. at Continental Col'ry, 1876 (4 killed)
22	Th.	Pilgrims settled at Plymouth, Mass., 1620.
23	F.	James II. abdicated, 1688.
24	S.	Hugh Miller died, 1856.
25	S.	**Christmas Day.** Sir Isaac Newton born, 1642.
26	M.	Siege of Metz, 1552.
27	Tu.	John Kepler born, 1581.
28	W.	Tay Bridge Disaster, Scotland, 1879.
29	Th.	W. E. Gladstone born, 1809.
30	F.	The Monitor sunk, 1862.
31	S.	Empire Mine fire discovered, 1874.

DIARY

AND

CASH ACCOUNT.

1881

2, Mon.

3, Tues.

4, Wed.

5, Thurs.

6, Fri.

7, Sat.

9, Mon.

10, Tues.

11, Wed.

12, Thurs.

13, Fri.

14, Sat.

16 Mon.

17, Tues.

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31, Tues.

1 June, W.

2, Thurs.

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30, Thurs.

1 July—Fri.

2, Sat.

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1 Oct.—Sat.

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31, Mon.

1 Nov.—Tu.

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24, Sat.

26, Mon.

27, Tues.

28, Wed.

29, Thurs.

30, Fri.

31, Sat.

MAY, 1881.

RECEIVED.		CASH ACCOUNT.	PAID.	
DOLLARS.	CENTS.		DOLLARS.	CENTS.

JUNE, 1881.

RECEIVED.		CASH ACCOUNT.	PAID.	
DOLLARS.	CENTS.		DOLLARS.	CENTS.

JULY, 1881.

RECEIVED.		CASH ACCOUNT.	PAID.	
DOLLARS.	CENTS.		DOLLARS.	CENTS.

AUGUST, 1881.

RECEIVED.		CASH ACCOUNT.	PAID.	
DOLLARS.	CENTS.		DOLLARS.	CENTS.

SEPTEMBER, 1881.

RECEIVED.		CASH ACCOUNT.	PAID.	
DOLLARS.	CENTS.		DOLLARS.	CENTS.

OCTOBER, 1881.

RECEIVED.		CASH ACCOUNT.	PAID.	
DOLLARS.	CENTS.		DOLLARS.	CENTS.

NOVEMBER, 1881.

RECEIVED.		CASH ACCOUNT.	PAID.	
DOLLARS.	CENTS.		DOLLARS.	CENTS.

DECEMBER, 1881.

RECEIVED.		CASH ACCOUNT.	PAID.	
DOLLARS.	CENTS.		DOLLARS.	CENTS.

MEMORANDA.

RATES OF POSTAGE.

FIRST-CLASS MATTER.—Includes letters, postal cards, and anything sealed or otherwise closed against inspection, or anything containing writing not allowed as an accompaniment to printed matter, under class three. Postage, three cents each half-ounce or fraction thereof. On local or drop letters, at free delivery offices, two cents. At offices where no free delivery by carrier, one cent. Pre-payment by stamps invariably required. Postal cards, one cent. Registered letters, ten cents in addition to the proper postage. The Post Office Department or its revenue is not by law liable for the loss of any registered mail matter.

SECOND CLASS.—Includes all newspapers, periodicals or matter exclusively in print and regularly issued at stated intervals as frequently as four times a year from a known office of publication or news agency. Postage, two cents a pound or fraction thereof, prepaid by special stamps. Publications designed primarily for advertising or free circulation, or not having a legitimate list of subscribers, are excluded from the pound rate, and pay third-class rates.

THIRD CLASS.—Includes books, transient newspapers and periodicals, circulars, and other matter wholly in print, legal and commercial papers filled out in writing, proof-sheets, corrected proof-sheets and manuscript copy accompanying the same. Manuscript unaccompanied by proof-sheets, letter rates. Limit of weight, four pounds each package, except single books—weight not limited. Postage, one cent for each two ounces or fractional part thereof, invariably prepaid by stamps.

FOURTH CLASS.—Embraces merchandise and all matter not included in the First, Second or Third Class, which is not liable to injure the mail matter. Limit of weight, four pounds. Postage, one cent each ounce or fraction thereof, prepaid. All packages of the Third or Fourth Class must be so wrapped or enveloped that their contents may be examined by postmaster without destroying the wrappers. Matter of the Second, Third or Fourth Class containing any writing except as here specified, or except bills and receipts for periodicals, or the date and name of the addressed and of the sender of circulars will be charged with letter postage; but the sender of any book may write names or addresses therein,

or on the outside, with the word "from" preceding the same, or may write briefly on any package the number and names of the articles inclosed.

POSTAL MONEY ORDERS.—An order may be issued for any amount, from one cent to fifty dollars, inclusive, but fractional parts of a cent cannot be included. The fees for orders are : on orders not exceeding $15, ten cents; over $15 and not exceeding $30, fifteen cents ; over $30 and not exceeding $40, twenty cents ; over $40 and not exceeding $50, twenty-five cents. When a larger sum than fifty dollars is required, additional orders must be obtained ; but no more than three orders will be issued in one day from the same post office to the same remitter in favor of the same payee.

INTERNAL REVENUE DUTIES.

Bankers' capital, $\frac{1}{24}$ of 1 per cent. per month.
Bankers' checks, 2 cents.
Bankers' deposits, $\frac{1}{12}$ of one per cent. per month.
Cigars, foreign or domestic, $6 per 1000.
Cigarettes, foreign or domestic, $1.75 per 1000, weighing not over three pounds.
Cigarettes, foreign or domestic, $6 per 1000, weighing over three pounds.
Chewing and smoking tobacco, twenty-four cents per pound.
Snuff, thirty-two cents per pound.
Distilled spirits, ninety cents per gallon.
Fermented liquors, $1 per barrel of thirty-one gallons.
Matches, in boxes containing 100 or less, one cent.
Matches, in boxes containing over 100 and less than 200, two cents.

PROPRIETARY ARTICLES.

Less than twenty-five cents, retail, one cent.
Over twenty-five and not over fifty cents retail, two cents.
Over fifty and not over seventy-five cents retail, three cents.
Over seventy-five and not over one hundred cents retail, four cents.

POPULATION OF ANTHRACITE COAL COUNTIES.

Luzerne	133,066	Northumberland	58,132
Schuylkill	129,977	Columbia	32,408
Lackawanna	89,628	Carbon	31,922

THE

MINE FOREMAN'S POCKET BOOK.

NAMES

OF THE

INSPECTORS OF MINES

OF THE

UNITED STATES.

PENNSYLVANIA.

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Second or Shenandoah District.—ROBERT MAUCHLINE, Esq., Shenandoah, Schuylkill County, Pa.

Third or Shamokin District.—JAMES RYAN, Esq., Shamokin, Pa.

Middle District of Luzerne, Lackawanna and Carbon Counties.—G. M. WILLIAMS, Esq., Wilkesbarre, Luzerne County, Pa.

Eastern District of Luzerne, Lackawanna and Carbon Counties.—PATRICK BLEWITT, Esq., Scranton, Lackawanna County, Pa.

South District of Luzerne, Lackawanna and Carbon Counties.—T. D. JONES, Esq., Hazleton, Luzerne County, Pa.

MINE INSPECTORS' CLERKS.

For the Mining District of Schuylkill.—E. J. GAYNOR, Esq., Pottsville, Schuylkill County, Pa.

For the Mining District of Luzerne and Carbon Counties.—MICHAEL MCNERTNEY, Esq., Wilkesbarre, Luzerne, County, Pa.

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Mining District of Schuylkill County.

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R. W. ROBERTS, Esq., St. Nicholas, Schuylkill Co., Pa.

JAMES MCLAUGHLIN, Esq., Cumbola, Schuylkill Co., Pa.

THOMAS CROWE, Esq., New Mines, Schuylkill Co., Pa.

Luzerne and Carbon Counties.

BENJAMIN HUGHES, Esq., Hyde Park, Lackawanna County, Pa.

JOHN R. DAVIS, Esq., Scranton, Lackawanna Co., Pa.

JAMES O'HALLORAN, Esq., Moosic, Luzerne Co., Pa.

WILLIAM BESTFORD, Esq., Port Blanchard, Pa.

JAMES BRYDEN, Esq., Pittston, Lackawanna Co., Pa.

BITUMINOUS REGION.

First District (*embracing the counties of Greene, Washington, Fayette, Somerset, Bedford, Westmoreland, and that portion of Allegheny County lying south of the Ohio and Allegheny rivers*).—WILLIAM WILCOX, Esq., Mansfield, Allegheny County, Pa. Appointed July 10th, 1877.

Second District (*embracing the counties of Beaver, Lawrence, Mercer, Crawford, Erie, Warren, Forest, Venango, Clarion, Jefferson, Indiana, Armstrong, Butler, and that portion of Allegheny County lying north of the Ohio and Allegheny rivers*).—J. L. DAVIS, Esq., Brady's Bend, Armstrong County, Pa. Appointed July 10th, 1877.

Third District (*embracing the counties of Cambria, Blair, Huntingdon, Centre, Clearfield, Elk, Cameron, McKean, Potter, Clinton, Lycoming, Bradford and Tioga*).—WILLIAM L. RICHARDS, Esq., Blossburg, Tioga County, Pa. Appointed July 10th, 1877.

OHIO.

For the State.—ANDREW ROY, Esq., Columbus, O.

IOWA.

For the State.—PARKER C. WILSON, Esq., Des Moines, Ia.

MARYLAND.

District of Allegheny and Garrett Counties.—THOMAS BROWN, Esq., Cumberland, Allegheny County, Md.

ILLINOIS.

The county boards in each of the mining counties of Illinois appoint, at the September meeting, one Inspector of Mines, who shall have been a resident of the county for which he is appointed for one year previous to his appointment, and shall be required to enter into a bond for the faithful discharge of his duties. He shall also take an oath of office as prescribed by the constitution. His term of office is one year, but he may be reappointed as often as it is thought proper. The county board fixes the number of days to be employed by the county Inspector in inspecting the different mines of his county, and the inspector receives such compensation for time actually employed in the performance of his official duties as shall be fixed by the county board, to be not less than three dollars nor more than five dollars per day, to be paid out of the county treasury. Where non-compliance with mining laws occurs, it is the county Inspector's duty to demand, and, if necessary, compel by law, the collection from owners or operators of such mine of all expenses of such inspections.

Name.	County.	P. O. Address.
A. H. Johnson,	Clinton,	Carlyle.
F. H. Setters,	Gallatin,	Shawneetown.
F. H. Setters,	Grundy,	Morris.
P. Kelly,	Will,	Braidwood.
E. C. Rossetter,	Henry,	Cambridge.
W. C. Tipton,	Jackson,	Murphysboro.
James O'Malley,	La Salle,	Ottawa.
John Reese,	Livingstone,	Pontiac.
J. H. Rhodes,	Logan,	Lincoln.
Joseph Schwager,	Madison,	Edwardsville.
Thomas Rose,	Mercer,	Aledo.
Wm. S. Woods,	Menard,	Petersburg.
John Craig,	Macoupin,	Carlinville,
Charles McShays,	Peoria,	Peoria.
R. B. Houston,	Randolph,	Cluster.
Wm. Lee,	Rock Island,	Coal Valley.
David Cummings,	Sangamon,	Springfield.
Joseph Lamb,	Tazwell,	Pekin.
T. S. McClanahan,	Warren,	Monmouth.
James Thompson,	Williamson,	Marion.
Martin Deavey,	Woodford,	Metamora.
James Brucewell,	Vermillion,	Danville.

AREA OF THE COAL FIELDS OF THE UNITED STATES, AND PRODUCTION FOR 1879.

	States and Territories.		Area square miles.	Tons produced in 1869, (U. S. census, 1870.)	Value, 1870.	Tons produced in 1879, (Saward's estimate.)
1	Pennsylvania	Anthracite	472	15,664,275	$38,436,745	26,142,689
		Bituminous	12,302	7,798,518	13,921,069	14,500,000
2	Ohio,	Bituminous	10,000	2,527,285	5,482,952	5,000,000
3	Illinois,	do	36,800	2,621,163	6,097,432	3,500,000
4	Maryland,	do	550	1,819,824	2,409,205	1,730,709
5	W. Virginia,	do	16,000	608,878	1,035,862	1,250,000
6	Iowa,	do	18,000	263,487	874,331	1,600,000
7	Indiana,	do	6,450	437,870	988,621	1,000,000
8	Missouri,	do	26,887	621,930	2,011,520	900,000
9	Kentucky,	do	12,871	150,582	446,795	1,000,000
10	Tennessee,	do	5,100	133,118	330,198	450,000
11	California,	do	.....	.....	.....	600,000
12	Colorado,	do	.....	4,500	16,500	400,000
13	Kansas,	do	.....	32,938	111,278	400,000
14	Oregon,	do	22,256	.....	.....	200,000
15	Alabama,	do	.....	11,000	39,000	250,000
16	Washington,	do	5,330	17,811	107,061	170,000
17	Wyoming,	do	.....	50,000	800,000	175,000
18	Virginia,	do	.....	61,803	226,114	90,000
19	Michigan,	do	185	28,150	104,200	35,000
20	Nebraska,	do	6,700	1,425	8,550	75,000
21	Utah,	do	3,000	5,800	14,950	225,000
22	R. Island,	do	.....	11,000	59,000	15,000
23	Arkansas,	do	500	.....	.....	.....
24	Texas,	do	12,000	.....	.....	.....
25	Georgia,	do	20,000	.....	.....	100,000
	Total		.....	32,863,690	$73,524,992	59,808,398

The coal production of Great Britain for the year 1879 was 134,008,228 tons. The number of collieries in the United Kingdom was 3,877.

For 1880, the Anthracite coal production of the United States was 23,437,242 tons, and Mr. F. E. Saward, of New York, estimates the bituminous production to have been 37,000,000, making a total production of 60,437,242 tons.

COAL AREAS AND OUT-PUT OF THE GLOBE.

Countries.	Area Square Miles.	Tons—1870.	Tons—1878.
Great Britain	11,900	110,431,192	†132,607,866
United States	192,000	32,863,690	*49,130,584
Germany	1,770	34,003,004	50,400,925
France	2,086	13,179,708	17,096,500
Belgium	510	13,697,118	14,899,175
Austria	1,800	8,355,944	14,500,000
Russia	30,000	829,745	1,709,269
Spain	3,501	661,927	765,000
Nova Scotia	18,000	625,769	788,000
Australia	24,840	868,564	1,575,926
India	2,004	500,000	4,000,000
Japan	5,000	.....	600,000
Vancouver's Island	390	29,863	228,974
China, Chili, etc.	.....	4,000,000	4,360,000
Total	293,801	214,046,524	292,652,219

*For the year 1880, 60,437,242 tons.

†For the year 1879, 134,008,228 tons.

ANTHRACITE COAL TONNAGE BY DECADES.

Year.	Schuylkill.	Lehigh.	Wyoming.	Total.
1820	.....	365	.....	.....
1830	89,934	41,750	43,000	174,734
1840	490,596	225,313	148,470	864,384
1850	1,840,620	690,456	827,823	3,358,899
1860	3,749,632	1,821,674	2,941,817	8,513,123
1870	4,851,855	3,172,916	7,825,128	15,849,899
1880	7,554,742	4,463,221	11,419,279	23,437,242

ANTHRACITE COAL TONNAGE OF LAST DECADE BY REGIONS.

Year.	Schuylkill.	Lehigh.	Wyoming.	Total.
1871.....	6,314,422	2,115,683	6,683,302	15,113,407
1872.....	6,469,912	3,743,278	8,812,905	19,026,125
1873.....	6,294,769	3,243,168	10,047,241	19,585,178
1874.....	5,642,180	4,047,656	9,290,910	18,980,726
1875.....	6,281,712	2,834,605	10,596,155	19,712,472
1876.....	6,221,934	3,854,919	8,424,158	18,501,311
1877.....	8,195,042	4,332,760	8,300,377	20,828,179
1878.....	6,282,226	3,237,449	8,085,587	17,605,262
1879.....	8,960,329	4,595,567	12,586,293	26,142,689
1880.....	7,554,742	4,463,221	11,419,279	23,437,242

According to Mr. John H. Jones, accountant for the Anthracite coal companies, the stock of coal on hand at tide-water shipping points, December 31st, 1880, was 500,273 tons; on November 30th, 609,833 tons; decrease, 109,560 tons. The amount on hand December 31st, 1879, was 613,512 tons; and on December 31st, 1878, 501,377 tons.

Of the total production in 1880, 11,419,279 tons, or 48.72 per cent., was from the Wyoming Region; 4,463,221 tons, or 19.05 per cent., from Lehigh Region, and 7,554,-742 tons, or 32.23 per cent., from Schuylkill Region.

Competitive tonnage, including all Coal which for final consumption, or in transit, reaches any point on Hudson River or the Bay of New York, or which passes out of the Capes of the Delaware, except Pea and Dust.

1879.....11,813,798 tons.
1880.....10,088,159 "

ANTHRACITE COAL TONNAGE FOR 1880, COMPARED WITH 1879.

Compiled by Mr. John H. Jones.

	For Year 1880.	For Year 1879.	Difference.
Philad'a & Reading R. R.	5,933,922 14	7,442,617 04	Dec. 1,508,694 10
Lehigh Valley R. R.	4,394,532 14	4,405,957 13	Dec. 11,424 19
Central R. R. of N. J.	3,470,141 02	3,825,553 07	Dec. 355,412 05
Del., Lacka. & W. R. R.	3,550,348 05	3,867,404 11	Dec. 317,056 06
Del. & Hud. Canal Co.	2,674,704 18	3,014,117 06	Dec. 339,412 08
Pennsylvania R. R.	1,864,031 15	1,682,106 10	Inc. 181,925 05
Penn'a Coal Co.	1,138,466 05	1,427,150 03	Dec. 288,683 18
N. Y., L. E. & W. R. R.	411,094 11	477,782 15	Dec. 66,688 04
Total	23,437,242 04	26,142,689 09	Dec. 2,705,447 05

ANTHRACITE COAL AREAS OWNED BY THE SEVERAL COMPANIES IN THE DIFFERENT COAL FIELDS AND THE PER CENT. OF THE WHOLE IN TONS.

From Mr. P. W. Sheafer's Diagram.

	Schuylkill		Middle.		Wyoming.	
	Acres.	Per Cent	Acres.	Per Cent	Acres.	Per Cent
Lehigh Valley	.....	.....	18,036	24	6,934	4
Lehigh and Wilkesbarre	7,600	8	7,000	8	7,400	5
Delaware and Hudson	.....	.....	.....	.....	20,042	12
Delaware, Lack. & Western	.....	.....	.....	.....	3,500	3
Pennsylvania Coal Co.	.....	.....	.....	.....	10,000	6
Phil. & Read. Coal & Iron Co.	65,306	70	23,250	32	.....	.....
Pennsylvania Railroad Co.	6,000	6	9,000	9	5,823	6
Girard Estate	.....	.....	6,000	8	.....	.....
Gilbert & Co.	.....	.....	1,373	2	.....	.....
Alliance Coal Mining Co.	3,172	3	.....	.....	.....	.....
All others	11,362	13	15,981	17	73,021	64
Total	93,440	100	80,640	100	126,720	100

LOWEST AND HIGHEST PRICES OF ANTHRACITE COAL, BAR IRON, AND SCOTCH PIG IRON, IN THE NEW YORK MARKET, FOR FIFTY-SIX YEARS.—1825-1880.

From Spofford's American Almanac.

Year	Anthracite Coal.		Iron, Bar. Ton.		Iron, Scotch Pig.	
	L. Ton.	H.	L.	H.	L. Ton.	H.
1825	$8 00	$11 00	$85 00	$120 00	$35 00	$75 00
1826	11 00	12 00	85 00	100 00	50 00	70 00
1827	10 50	12 50	77 00	95 00	50 00	55 00
1828	10 00	12 00	77 50	82 50	50 00	55 00
1829	10 00	12 00	72 50	82 50	40 00	55 00
1830	7 00	12 00	72 50	77 50	40 00	50 00
1831	6 00	9 00	70 00	80 00	40 00	47 50
1832	8 50	16 00	70 00	75 00	40 00	47 50
1833	5 50	10 00	71 00	75 00	37 50	47 50
1834	5 50	6 50	67 00	75 00	37 50	48 00
1835	5 50	9 00	67 50	75 00	38 00	42 50
1836	7 00	11 00	75 00	105 00	38 00	62 50
1837	8 50	11 00	85 00	105 00	40 00	70 00
1838	7 00	9 50	85 00	97 50	37 50	55 00
1839	6 50	9 00	82 50	95 00	37 50	45 00
1840	6 00	8 50	70 00	82 50	32 50	40 00
1841	6 50	9 00	60 00	75 00	32 00	37 50
1842	5 00	9 00	50 00	62 50	23 50	35 00
1843	4 50	6 00	55 00	60 00	22 50	32 00
1844	4 25	6 00	57 00	65 00	30 00	35 00
1845	4 50	6 00	62 50	85 00	30 00	52 50
1846	5 00	7 00	75 00	80 00	35 00	42 50
1847	5 00	7 00	70 00	77 50	30 00	42 50
1848	4 50	6 00	50 00	70 00	25 00	37 50
1849	5 00	6 00	40 00	55 00	22 50	27 50
1850	5 00	7 00	40 00	45 00	21 00	24 00
1851	4 25	7 00	33 50	41 00	19 00	25 00
1852	5 00	7 00	34 00	55 00	19 00	31 00
1853	5 00	7 00	55 00	75 00	28 50	38 00
1854	6 00	7 50	62 50	77 50	32 00	42 50
1855	5 50	7 50	55 00	65 00	26 50	37 00
1856	5 50	6 50	50 00	65 00	29 00	37 00
1857	6 00	7 00	52 00	62 50	28 00	37 50
1858	5 00	6 00	44 00	55 00	22 00	27 00
1859	5 25	5 50	42 50	50 00	22 00	31 50
1860	5 50	6 00	41 00	44 00	20 50	27 00
1861	4 20	6 00	38 00	50 00	20 00	24 50
1862	4 25	8 50	50 00	70 00	21 00	33 00

Year	Anthracite Coal. L. Ton.	Anthracite Coal. H.	Iron, Bar. Ton. L.	Iron, Bar. Ton. H.	Iron, Scotch, Pig. L. Ton.	Iron, Scotch, Pig. H.
1863	$7 00	$11 00	$65 00	$76 00	$32 50	$45 00
1864	9 00	15 00	105 00	220 00	43 00	80 00
1865	8 50	13 50	100 00	130 00	40 00	55 00
1866	8 50	13 00	94 00	115 00	42 00	55 00
1867	6 50	8 50	80 00	100 00	38 00	49 00
1868	6 50	11 50	80 00	95 00	35 00	45 75
1869	6 50	10 50	85 00	95 00	34 50	45 00
1870	4 50	8 50	70 00	90 00	31 00	37 00
1871	5 00	13 00	70 00	95 00	30 00	39 00
1872	3 75	6 25	85 00	120 00	33 50	61 00
1873	5 00	6 50	75 00	110 00	37 00	52 00
1874	4 55	5 55	55 00	80 00	33 00	45 00
1875	4 40	5 55	50 00	62 50	29 00	41 00
1876	3 75	5 55	40 00	54 00	27 50	34 00
1877	3 25	3 75	44 80	48 72	25 00	28 00
1878	2 75	4 50	42 50	45 00	21 50	26 50
1879	2 15	3 25	45 00	78 50	19 00	30 50
1880	3 50	4 45	46 00	76 00	20 00	40 00

PRICES OF COAL TO LINE AND CITY AT SCHUYLKILL HAVEN DURING THE YEAR 1880.

Compiled by Mr. Frank P. Kendrick.

	Lump.	Steamboat.	Broken.	Egg.	Stove and Small Stove	Chestnut.	Pea.
Jan	$2 65	$2 65	$2 65	$2 65	$2 90	$2 65	$1 55
Feb.....	2 75	2 75	2 50	2 50	2 60	2 50	1 50
March...	3 00	3 00	2 75	2 50	2 60	2 50	1 50
April.....	3 00	3 00	2 75	2 50	2 60	2 50	1 50
May	3 00	3 00	2 75	2 50	2 60	2 50	1 50
June	3 00	3 00	2 75	2 50	2 75	2 50	1 50
July	3 00	3 00	2 75	2 75	2 75	2 50	1 75
August..	3 00	3 00	2 75	2 75	2 75	2 50	1 75
Sept.....	3 00	3 00	3 00	3 00	3 00	2 75	1 75
Oct.....	3 00	3 00	3 00	3 00	3 00	2 75	1 75
Nov	3 00	3 00	3 00	3 00	3 00	2 75	1 75
Dec	3 00	3 00	3 00	3 00	3 00	2 75	1 75

HARBOR (F. O. B.) PRICES AT PORT RICHMOND DURING YEAR 1880 FOR HARD WHITE ASH.

	Lump.	Steamboat.	Broken.	Egg.	Stove.	Chestnut.	Pea.
Jan.....	$3 95	$3 95	$3 85	$3 95	$4 20	$3 70	$2 85
Feb.....	4 25	4 25	3 85	3 85	3 95	3 85	2 85
March...	4 50	4 50	4 10	3 85	3 95	3 85	2 85
April.....	4 70	4 70	4 35	4 10	4 20	4 10	3 10
May.....	4 70	4 70	4 35	4 10	4 20	4 10	3 10
June	4 70	4 70	4 35	4 10	4 35	4 10	3 10
July.....	4 70	4 70	4 35	4 35	4 35	4 10	3 35
August..	4 70	4 70	4 35	4 35	4 35	4 10	3 35
Sept	4 60	4 60	4 60	4 60	4 60	4 35	3 35
Oct.....	4 60	4 60	4 60	4 60	4 60	4 35	3 35
Nov.....	4 60	4 60	4 60	4 60	4 60	4 35	3 35
Dec.....	4 60	4 60	4 60	4 60	4 60	4 35	3 35

PRICES OF HARD WHITE ASH COAL (F. O. B.) AT PORT RICHMOND, BEYOND THE CAPES OF DELAWARE, DURING YEAR 1880.

	Lump.	Steamboat.	Broken.	Egg.	Stove.	Chestnut	Pea.
Jan. 3....	$3 90	$3 90	$3 60	$3 60	$4 00	$3 50	$2 50
Feb. 19..	4 25	4 25	3 25	3 25	3 65	3 50	2 25
Mar. 15..	4 40	4 40	3 65	3 65	3 65	3 55	2 40
April.....	4 65	4 65	3 90	3 90	3 65	3 65	2 65
May 10..	4 65	4 65	3 90	3 90	3 90	3 65	2 65
June	4 65	4 65	3 90	3 90	3 90	3 65	2 65
July	4 65	4 65	3 90	3 90	3 90	3 65	2 65
August..	4 65	4 65	3 90	3 90	3 90	3 65	2 65
Sept.....	4 65	4 65	4 05	4 10	4 10	3 65	2 65
Oct.....	4 65	4 65	4 05	4 10	4 10	3 65	2 65
Nov.....	4 65	4 65	4 05	4 10	4 10	3 65	2 65
Dec.....	4 65	4 65	4 05	4 10	4 10	3 65	2 65

PRICES OF HARD WHITE ASH (F. O. B.) AT ELIZABETHPORT, N. J., DURING THE YEAR 1880.

	Lump.	Steamboat.	Broken.	Egg.	Stove.	Chestnut.	Pea.
Jan. 3...	$4 25	$4 25	$3 95	$3 95	$4 25	$3 75	$2 75
Feb. 19..	4 75	4 75	3 60	3 60	4 00	3 85	2 50
Mar. 15..	4 75	4 75	4 00	4 00	4 00	3 90	2 75
April.....	5 00	5 00	4 25	4 25	4 00	4 00	3 00
May 10..	5 00	5 00	4 25	4 25	4 25	4 00	3 00
June	5 00	5 00	4 25	4 25	4 25	4 00	3 00
July.....	5 00	5 00	4 25	4 25	4 25	4 00	3 00
August..	5 00	5 00	4 25	4 25	4 25	4 00	3 00
Sept	5 00	5 00	4 40	4 45	4 45	4 00	3 00
Oct.....	5 00	5 00	4 40	4 45	4 45	4 00	3 00
Nov.....	5 00	5 00	4 40	4 45	4 45	4 00	3 00
Dec	5 00	5 00	4 40	4 45	4 45	4 00	3 00

LINE PRICES AT MAUCH CHUNK DURING YEAR 1880.

Compiled by Mr. Frank P. Kendrick.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Lump, Furn...	2 75	2 75	3 00	3 00	3 00	3 00	3 00	3 00	3 25	3 25	3 25	3 25
" Selected	.....	.....	.....	.....	3 75	3 75	3 75	4 00	4 00	4 00	4 00	4 00
Steamboat	2 75	2 75	3 00	3 00	3 00	3 00	3 00	3 00	3 25	3 25	3 25	3 25
Broken.....	2 50	2 50	2 75	2 75	2 75	2 75	3 00	3 00	3 25	3 25	3 25	3 25
Egg	2 50	2 50	2 75	2 75	2 75	2 75	3 00	3 00	3 25	3 25	3 25	3 25
Stove	2 60	2 60	2 85	2 85	2 85	3 00	3 00	3 00	3 25	3 25	3 25	3 25
Small Stove...	2 60	2 60	2 85	2 85	2 85	3 00	3 00	3 00	3 25	3 25	3 25	3 25
Chestnut.....	2 50	2 50	2 75	2 75	2 75	2 75	2 75	2 75	3 00	3 00	3 00	3 00
Pea	1 50	1 50	1 75	1 75	1 75	1 75	1 75	1 75	2 00	2 00	2 00	2 00

PHILADELPHIA AND TRENTON PRICES AT MAUCH CHUNK FOR 1880.

	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Lump, Furnace	3 00	3 00	3 00	3 00	3 00	3 00	3 00	3 00	3 00	3 00
" Selected	.....	.....	3 75	3 75	3 75	4 00	4 00	4 00	4 00	4 00
Steamboat	3 00	3 00	3 00	3 00	3 00	3 00	3 00	3 00	3 00	3 00
Broken	2 75	2 75	2 75	2 75	2 75	2 75	3 00	3 00	3 00	3 00
Egg	2 50	2 50	2 50	2 50	2 75	2 75	3 00	3 00	3 00	3 00
Stove	2 60	2 60	2 60	2 75	2 75	2 75	3 00	3 00	3 00	3 00
Small Stove	2 60	2 60	2 60	2 75	2 75	2 75	3 00	3 00	3 00	3 00
Chestnut	2 50	2 50	2 50	2 50	2 50	2 50	2 75	2 75	2 75	2 75
Pea	1 50	1 50	1 75	1 75	1 75	1 75	1 75	1 75	1 75	1 75

EXPENSES TO PHILADELPHIA VIA MAUCH CHUNK FOR 1880.

By railroad	$1 90	in April.
By boats, re-shipped at Camden	1 70	" "
By railroad	1 90	" May.
By boats, re-shipped at Camden	1 70	" "
By railroad	1 90	" June.
By boats, re-shipped at Camden	1 70	" "
By railroad	1 90	" July.
By boats, re-shipped at Camden	1 70	" "
By railroad	1 90	" August.
By boats, re-shipped at Camden	1 70	" "
By railroad	1 90	" Septem'r
By boats, re-shipped at Camden	1 70	" "
By railroad	1 90	" October.
By boats, re-shipped at Camden	1 70	" "
By railroad	1 90	" Novem'r
By boats, re-shipped at Camden	1 70	" "
By railroad	1 90	" Decem'r.
By boats, re-shipped at Camden	1 70	" "

Five cents additional expense for shipment by boat from Camden to Philadelphia.

COAL DEALERS' COMPUTING TABLE FOR ASCERTAINING THE PRICE ON ANY NUMBER OF POUNDS AT A GIVEN PRICE PER TON OF 2000 POUNDS.

FRACTIONS OF A TON.

Prepared by Whitney, McCreary and Kemmerer, Philadelphia.

Lbs.	$2 75	$3 00	$3 25	$3 50	$3 75	$4 00	$4 25	$4 50	$4 75	$5 00	$5 25	$5 50	$5 75	$6 00	$6 25	$6 50	$6 75
10	01	02	02	02	02	02	02	03	03	03	03	03	03	03	03	03	03
20	03	03	03	04	04	04	05	05	05	05	06	06	06	06	06	07	07
30	04	05	05	05	06	06	07	07	07	08	08	08	09	09	09	10	10
40	06	06	07	07	08	08	09	09	10	10	11	11	12	12	13	13	14
50	07	08	08	09	09	10	11	12	12	13	13	14	15	15	16	16	17
60	08	09	10	11	11	12	13	14	15	15	16	17	18	18	19	20	20
70	10	11	11	12	13	14	15	16	17	18	19	19	20	21	22	23	24
80	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
90	12	14	15	16	17	18	19	20	22	23	24	25	26	27	28	29	31
100	14	15	16	18	19	20	22	23	24	25	27	28	29	30	31	33	34
200	28	30	33	35	38	40	43	45	48	50	53	55	58	60	63	65	68
300	41	45	49	53	56	60	64	68	72	75	79	83	87	90	94	98	1 01
400	55	60	65	70	75	80	85	90	95	1 00	1 05	1 10	1 15	1 20	1 25	1 30	1 35
500	69	75	81	88	94	1 00	1 07	1 13	1 19	1 25	1 32	1 38	1 44	1 50	1 56	1 63	1 69
600	83	90	98	1 05	1 13	1 20	1 28	1 35	1 43	1 50	1 58	1 65	1 73	1 80	1 88	1 95	2 03
700	96	1 05	1 14	1 23	1 31	1 40	1 49	1 58	1 67	1 75	1 84	1 93	2 02	2 10	2 19	2 28	2 36
800	1 10	1 20	1 30	1 40	1 50	1 60	1 70	1 80	1 90	2 00	2 10	2 20	2 30	2 40	2 50	2 60	2 70
900	1 24	1 35	1 46	1 58	1 69	1 80	1 92	2 03	2 14	2 25	2 37	2 48	2 59	2 70	2 81	2 93	3 04
1000	1 38	1 50	1 63	1 75	1 88	2 00	2 13	2 25	2 38	2 50	2 63	2 75	2 88	3 00	3 13	3 25	3 38
1100	1 51	1 65	1 79	1 93	2 06	2 20	2 34	2 48	2 62	2 75	2 89	3 03	3 17	3 30	3 44	3 58	3 72
1200	1 65	1 80	1 95	2 10	2 25	2 40	2 55	2 70	2 85	3 00	3 15	3 30	3 45	3 60	3 75	3 90	4 05
1300	1 79	1 95	2 11	2 28	2 41	2 60	2 77	2 93	3 09	3 25	3 42	3 58	3 75	3 90	4 07	4 23	4 39
1400	1 93	2 10	2 28	2 45	2 63	2 80	2 98	3 15	3 33	3 50	3 68	3 85	4 03	4 20	4 38	1 55	4 73
1500	2 06	2 25	2 44	2 63	2 81	3 00	3 19	3 38	3 57	3 75	3 94	1 13	1 32	4 50	4 69	4 88	5 07
1600	2 20	2 40	2 60	2 80	3 00	3 20	3 40	3 60	3 80	4 00	4 20	4 40	4 60	4 80	5 00	5 20	5 40
1700	2 31	2 55	2 76	2 98	3 19	3 40	3 62	3 83	4 04	4 25	4 47	4 68	4 89	5 10	5 32	5 53	5 74
1800	2 48	2 70	2 93	3 15	3 38	3 60	3 83	4 05	1 28	1 50	4 73	4 95	5 18	5 40	5 63	5 85	6 08
1900	2 61	2 85	3 09	3 33	3 56	3 80	4 01	4 28	4 52	4 75	4 99	5 23	5 47	5 70	5 94	6 18	6 42

RATING OF COLLIERIES SHIPPING BY PHILADELPHIA & READING RAILROAD.

East Mahanoy, Mahanoy and Shamokin, and Mine Hill North, District. J. H. OLHAUSEN, Supt.

Name of Colliery.	Name of Operator.	Date of Last Rating	Rated Capacity Per Day.
North Star	Reynolds, Roberts & Co.	11, 4, 80	38
Schuylkill	P. & R. C. & I. Co	2, 8, 81	70
North Mahanoy	" "	4, 30, 78	113
Mahanoy City	" "	3, 7, 78	110
Tunnel Ridge	" "	2, 9, 81	90
St. Nicholas	" "	12, 9, 79	111
Coal Run	Suffolk Coal Co	9, 21, 80	140
Ellangowan	P. & R. C. & I. Co.	3, 3, 80	240
Knickerbocker	" "	11, 8, 79	156
Bear Run	" "	4, 9, 80	104
Boston Run	" "	4, 9, 80	102
Draper		10, 29, 80	110
Gilberton	P. & R. C. & I. Co.	4, 8, 80	40
Furnace	" "	6, 7, 80	59
Lawrence	Lawrence, Merkel & Co.	4, 20, 80	141
West Bear Ridge	Myers, McCreary & Co.	4, 19, 80	113
Colorado	Phila. Coal Co.	10, 17, 78	150
Shenandoah	" "	10, 18, 78	144
William Penn	Wm. Penn Coal Co	3, 16, 80	210
Turkey Run	P. & R. C. & I. Co.	4, 7, 80	122
West Shenandoah	" "	4, 15, 80	130
Kohinoor	R. Heekseher & Co.	9, 15, 80	200
Shenandoah City	P. & R. C. & I. Co.	9, 24, 79	64
Plank Ridge	" "	5, 18, 80	125
Keely Run	Thomas Coal Co.	11, 4, 78	190
Conner	P. & R. C. & I. Co.	5, 12, 80	140
Girard Mammoth	" "	11, 25, 79	55
Cuyler	S. M. Heaton & Co	3, 4, 80	190
Preston, No. 2	P. & R. C. & I. Co.	10, 23, 78	120
Continental	Lehigh Valley Coal Co.	10, 21, 78	137
Centralia	" " "	11, 11, 78	121
Hazel Dell	Sykes & Jones	11, 1, 78	28
North Ashland	P. & R. C. & I. Co.	5, 26, 80	135
Bast	" "	3, 14, 79	150
Big Mine Run	J. Taylor & Co.	1, 21, 80	160
Tunnel	P. & R. C. & I. Co.	2, 14, 81	16
Girard	" "	5, 26, 76	120
Preston, No. 3	" "	6, 3, 80	126
Relianee	" "	6, 7, 80	126
Mt. Carmel	Montelius, Robertson Co	1, 24, 81	136
Monitor	Geo. W. Johns & Bro.	11, 11, 79	144
Merriam	P. & R. C. & I. Co.	4, 5, 80	125
Potts	" "	4, 9, 78	140
Keystone	" "	2, 1, 81	25
Locust Spring	" "	5, 17, 80	132

Name of Colliery.	Name of Operator.	Date of Last Rating.	Rated Capacity Per Day,
Ben Franklin	Douty & Baumgardner	5, 10, 78	92
Enterprise	Enterprise Coal Co	2, 10, 81	157
Excelsior	Excelsior Coal M'g Co	11, 2, 76	110
Greenback	H. J. Toudy	8, 16, 80	57
Buck Ridge	May, Audenried & Co	11, 16, 78	114
Big Mountain	Patterson, Llewellyn & Co	5, 10, 80	166
Bear Valley	P. & R. C. & I. Co	10, 24, 78	155
Burnside	" "	5, 8, 77	81
North Franklin, No. 1.	" "	4, 3, 77	57
George Fales	" "	11, 26, 79	52
Stanton	Miller, Hoch & Co	4, 2, 80	116
Indian Ridge	P. & R. C. & I. Co	5, 12, 80	180
Elmwood	" "	6, 7, 78	82
Staffordshire	Jones, Ward & Co	1, 20, 80	20
East Bear Ridge	Myers, McCreary & Co	4, 2, 80	100
Hammond	P. & R. C. & I. Co	5, 12, 80	100
Locust Gap	Graeber & Shepp	5, 19, 78	140
N. Franklin, No. 2	P. & R. C. & I. Co	5, 25, 80	112
Mt. Carmel Shaft	" "	4, 13, 80	200
Eureka	E. Gorman & Co	10, 16, 78	21
Webster	L. S. Baldwin	10, 13, 80	35
Oakdale	E. L. Powell	10, 14, 80	12
Cambridge	Cambridge Coal Co	10, 8, 77	7
Stirling	Kendrick & Co	11, 26, 79	117
Franklin	S. S. Bickel	1, 5, 81	60
Henry Clay, No. 1	J. Langdon & Co	11, 8, 78	152
Carson	P. Goodwill	10, 24, 78	25
Peerless	Cruikshank & Emes	9, 16, 78	74
Laurel Ridge	Jno. A. Dutter	4, 1, 80	30
Hillside	Smith, Williams & Co	1, 25, 81	22
Beechwood	P. & R. C. & I. Co	11, 18, 79	90
Wadesville	" "	12, 19, 79	177
Monitor	Jno. Denning	10, 12, 77	13
Eagle	Geo. W. Johns & Bro	4, 24, 78	74
St. Clair	Jos. Atkinson & Co	10, 28, 78	7
Eagle Hill	P. & R. C. & I. Co	12, 10, 79	102
Coal Hill	R. Holahan & Bro	5, 20, 78	9
Palmer Vein	Alliance Coal Mining Co	5, 1, 76	61
Pottsville	P. & R. C. & I. Co	12, 18, 79	96
Pine Dale	Louis Lorenz	2, 1, 81	30
		Total ..	8684

The facts considered in rating collieries are :

First.—The number of mine cars that can be produced daily and their capacity in tons.

Second.—The capacity of the engines to hoist the coal produced.

Third.—The capacity of the breaker to prepare the coal.

MINE HILL, SOUTH DISTRICT.

A. A. Hesser, Supt.

Name of Colliery.	Name of Operator.	Rated Capacity Per Day.
Mine Hill Gap	P. & R. C. & I. Co	106
Richardson	" "	128
Glendower	" "	85
Phoenix Park, No. 2	" "	72
Forestville	" "	70
Otto	" "	100
Swatara	" "	69
Middle Creek Shaft	" "	100
East Franklin	" "	65
Thomaston	" "	125
Ellsworth	John R. Davis	25
Wolf Creek Big Diamond	E. Thomas	34
Black Heath	Wm. H. Harris	45
Black Mine	H. A. Moodie & Co	35
Wolf Creek Big Diamond	James Donahoe	20
Phoenix Park, No. 3	P. & R. C. & I. Co	92
Wolf Creek	Edward Hoskins	8
Dundas, No. 7	Davis & Co	3
	Total	1182

SCHUYLKILL AND SUSQUEHANNA, AND LEBANON AND TREMONT BRANCHES.

H. W. Tracy, Supt.

Name of Colliery.	Name of Operator.	Rated Capacity Per Day.
Brookside	P. & R. C. & I. Co	450
Colket	" "	102
Rausch Creek	Miller, Graeff & Co	140
Lincoln	Levi Miller & Co	200
Kalmia	Phillips & Sheaffer	123
	Total	1015

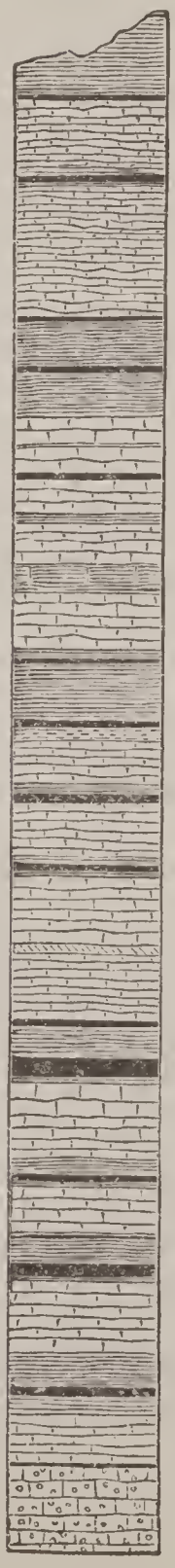
ANALYTICAL TABLE OF MINERAL FUEL.

No.	Name and Loaclity.	Density.	Free Carbon.	Total Carbon.	Hydro-gen.	Oxy-gen.	Water.	Ash.
1	Peat, general.....	.....	.. ....	28.09	5.93	30.37	30.05	5.62
2	Lignite, Rocky Mts	1.230	24.00	64.99	3.76	16.42	10.56	5.27
3	Anthracite	1.300	?	74.37	2.58	10.00	5.20	7.88
4	Cannel Coal, W. Va.....	1.300	23.00	82.00	5.16	8.04	2.25	2.55
5	Block Coal, Pa., W.Va., O., Ind.,	1.275	30.00	82.92	6.09	10.00	2.00	1.49
6	Coking Coal, general.....	1.400	15.00	85.90	5.46	5.00	2.00	1.64
	" " rich gas.....	1.350	25.00	84.00	6 00	5.00	3.00	2.00
7	Hard Anthracite, Penn.....	1.550	?	94.00	.40	1.26	2.30	2.50
8	Soft Anthracite, Penn.....	1.450	?	87.00	2.50	3.50	2.00	4.00
9	Dense Anthracite, New Eng.....	1.780	.....	80.00	.....,	.....	10.00	10.00

FORMULA OF THE GENERAL VARIETIES OF COAL.

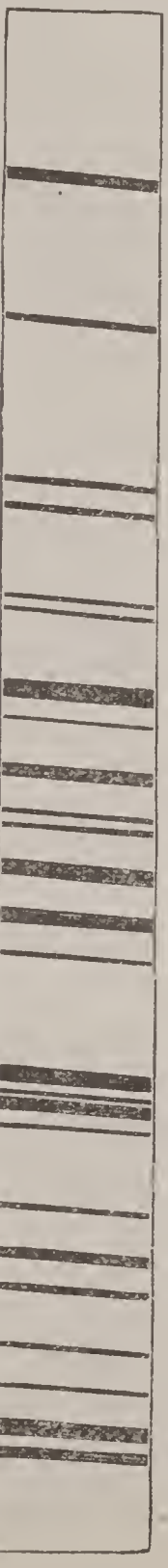
Constituents.	An-thracite.	Coking Coal.	Cherry or Block coal	Splint Coal.	Cannel Coal.	Lignite.
Carbon.....	92.56	87.952	83.025	82.924	75.25	64.00
Hydrogen	3.33	5.239	5.250	5.491	5.50	5.00
Nitrogen.....	?	?	?	?	1.61	?
Oxygen.....	2.53	3.806	8.566	8.847	13.83	26.00
Ash.....	1.58	1.393	1.549	1.128	2.81	4.00

Cross Section in the Southern Anthracite Coal Field of Pennsylvania.



Red Ash Coal,	3 ft.	Sandrock.
" "	7 ft.	Gate.
" "	3 ft.	Little Tracy.
" "	6 ft.	Tracy.
" "	6 ft.	Diamond.
" "	3 ft.	Little Orchard.
" "	6 ft.	Orchard.
Grey Ash Coal,	10 ft.	Primrose.
White Ash Coal,	5 ft.	Holmes.
" "	7 ft.	Seven Feet.
" "	25 ft.	Mammoth.
" "	6 ft.	Skidmore.
" "	9 ft.	Buck Mountain.
Red Ash Coal,	8 ft.	Lykens Valley, upp'r
" "	3 ft.	Lykens Valley, low'r
Total Coal,	107 ft.	

Cross Section Anthracite Coal Measures Nanticoke Basin.



Red Ash Coal, 4 ft. 6 in. — Tracy.

Pink Ash Coal, 4 ft. 4 in. — Diamond.

Gray Ash Coal, 6 ft. 6 in. — Orchard.

White Ash Coal, 7 ft. 2 in. — Hillman or Primrose.

" " " 4 ft. 3 in. — Cooper. } Baltimore, or

" " " 5 ft. 9 in. — Bennet } Mammoth.

" " " 12 ft. — Twin, Top Bench } Skid-
Twin, Bottom " } more.

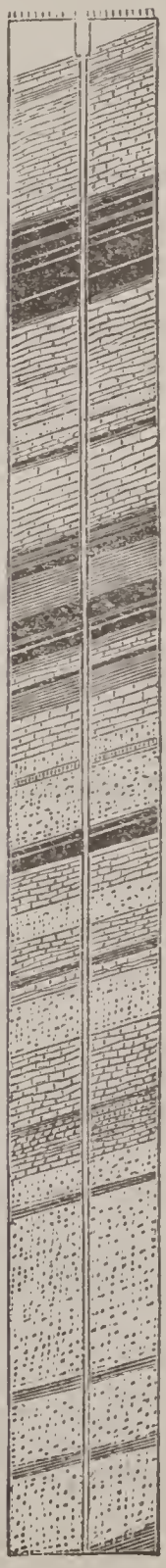
" " " 4 ft. 8 in. — Ross.

Red Ash Coal, 7 ft. 0 in. — Buck Mountain.

" " " 5 ft. 6 in. — Red Ash, Bench.

Total Coal, 61 ft. 8 in.

Cross Section at Crystal Ridge Colliery, Near Hazleton, Pa.



Dist. from Surface, 75 ft.

Mammoth Seam, 33 ft.

Dist. from Surface, 234 ft.

Wharton Seam, 8½ ft.

Dist. from Surface, 326 ft.

Buck Mt. Seam, 8 ft.

Total Coal, 49 ft. 6 in.

Total Depth, 640 ft. 7 in.

SPECIFIC GRAVITY.

To determine the specific gravity of coal, take a small piece of coal, suspend it by means of a horse hair from the under side of the pan of a carefully adjusted balance, and weigh it both in and out of water; divide its weight in the air *by the loss of weight* in the water, and the quotient is the specific gravity.

Example:

A piece of coal weighs say 480 grains.
Loss of weight when weighed in water, 398 grains.
Then $\frac{480}{398} = 1.206$, specific gravity of the coal compared with water at 1.000.

The following table gives the weight and specific gravity of various coals:

Name of Coal.	S. G.	Weight of a Cubic foot in lbs.	Weight of a cubic yard in tons.
Newcastle Hartley, Eng...	1.29	80.6	.972
Wigan, 4 feet, Eng.....	1.2	75.	.904
Portland, Eng	1.30	81.2	.978
Anthracite, Wales.....	1.39	86.9	1.047
Eglington, Scotland.....	1.25	78.1	.941
Anthracite, Irish.....	1.59	99.4	1.193
Anthracite, Penn.....	1.55	96.9	1.167
Bituminous, "	1.40	87.5	1.054
Block Coal, Ind.....	1.27	79.4	.956

PRODUCE OF COAL SEAMS.

A ready way of finding the quantity of available coal in a given area of a vein is given by W. Fairley, M. E., of England. He takes an acre of coal one inch thick to contain 100 tons. This leaves a sufficient margin for faults and loss of working, but will only apply to bituminous veins in the United States. Thus: a vein of coal twenty four inches thick will yield 2400 tons per acre.

To ascertain the exact quantity of anthracite or bituminous coal under a given area—presuming the vein to be of

regular thickness and quality throughout—find the specific gravity; then, as this represents the weight of a cubic foot in ounces, it is simply a matter of calculation to obtain the gross weight.

The exact weight of coal veins can be got from the table below:

Specific gravity.	Weight in the natural bed, per acre, per inch thick, in tons.	Weight of a cubic foot in the broken state, in lbs.	
		Large coal.	Small coal.
1.10	111.411	42.62	37.12
1.15	116.475	44.56	38.81
1.20	121.540	46.50	40.50
1.25	126.604	48.43	42.18
1.30	131.668	50.37	43.87
1.35	136.732	52.31	45.56
1.40	141.796	54.25	47 25
1.45	146.860	56.18	48 93
1.50	151.925	58.12	50.62

The weight of coal in its broken state, that is, as it comes to the surface in cars or otherwise, will depend on its mechanical structure; it has been ascertained by experiments with bituminous coal in England that as brought to the surface it weighs, if large, in proportion to the solid coal as 62 is to 100, and the weight of the small as 54 is to 100.

If, then, the figures in the second column be multiplied by the number of inches any bituminous coal vein is in thickness, the result will be the contents per acre in tons.

SHOWING THE NUMBER OF TONS OF COAL UNDER A SQUARE MILE AT DIFFERENT THICKNESSES.

Feet.	Tons.	Feet.	Tons.
1	972,320	9	8,750,880
2	1,944,640	10	9,723,200
3	2,916,960	20	19,446,400
4	3,889,280	30	29,169,600
5	4,861,600	40	38,892,800
6	5,833,920	50	48,616,000
7	6,806,240	60	58,339,200
8	7,778,560	70	68,062,400

NET PRODUCT OF ANTHRACITE COAL VEINS.

In making calculations upon the net product—or amount of prepared coal that can be shipped from a given area of an anthracite coal vein—allowance must be made for the refuse in the vein, the loss in mining and in preparation. This allowance will vary with the vein, and will be far larger in the Mammoth vein than in those which are not so thick, and will be greater where all the benches of the vein are found together than where it is divided into two or more splits. The result of experience in the anthracite region appears to be that the larger the vein the smaller, proportionally, is the amount of coal saved. Samuel Gay, Esq., Mine Inspector for the Pottsville District, in his report for 1879, makes calculations upon two collieries located in the eastern portion of the Mahanoy District. In each case he estimated the thickness of the vein at 35 feet and allowed 28.5 per cent. for slate, refuse, &c. He estimates the loss in breaking down or preparation at 15 per cent. In the case of the Stanton colliery he found that but 691,297 tons had been saved, while 3,292,703 tons had been lost. At the Gilberton colliery 3,808,244 tons had been lost in mining and preparation, while the net product was but 1,244,796 tons. No reliable figures to represent the percentage that should be allowed for loss in mining and preparation can be given, as they will vary with every vein and with the topographical character of each lease.

Mr. Joseph S. Harris, Superintendent of the Central Railroad of New Jersey, in his report to the Receivers of the Philadelphia and Reading Coal and Iron Company upon the value of their lands, estimates that 27 per cent. of the contents of the whole of all the veins on the company's estate is all that can be shipped. This, in the opinion of most authorities, is too small an estimate, and in it there is certainly no allowance made for improvements on the present system of mining. The figures given above evidence that there is ample room for improvement in our methods of mining anthracite coal.

MINING NOTES.

PROSPECTING.

For prospecting mineral land and sinking artesian, salt and other wells, the diamond-pointed drilling machines of the Pennsylvania Diamond Drill Company, of Pottsville, Pa., and of the American Diamond Rock Boring Company, of New York,—both companies are interested in the same patents,—have superseded all other systems of drilling. In prospecting results wholly unattainable otherwise are accomplished. In hard or soft measures cores for the whole distance bored, whether perpendicular or horizontal, are secured. These are in the form of solid cylinders, showing clearly the stratification and mineral passed through, the size and quality of the veins, &c., thus furnishing valuable information in making contracts for shafting or tunnelling. The samples of mineral secured are not pieces of disintegrated vein matter, but perfect sections of the one body or seam, which can be labeled and preserved for future reference.

The average progress made in prospecting in the Anthracite coal region is from 50 to 100 feet per week, including all delays due to drawing core from holes, &c. In the bituminous region the average progress made is from 75 to 125 feet per week. Holes have been put down 2100 feet, the original size of hole being preserved to the bottom, and it is claimed that the limit of depth that can be reached has not as yet been found.

Artesian wells are put down much more rapidly with these drills than by any other method, and, as the holes are round and straight, it is claimed for them that they are better for pumps if pumps are required, and for water if a flowing well is struck.

SHAFTING AND TUNNELING.

Power drills driven by steam or compressed air are superseding hand-drilling in rock work. Much more rapid progress can be made with them and at less cost.

Compressed air is the preferable motor, as it can be carried for great distances without any considerable loss of power, and in many localities it is difficult to get rid of the exhaust steam. Then the working of the drill with compressed air affords a supply of pure fresh air that is frequently a very important desideratum.

Steel pointed rock drills are operated upon the "percussion" or "blow" principle, while the diamond-pointed drills are borers. With the diamond drills sinking by the long hole process has been very successfully conducted in the anthracite region. At the East Norwegian shafts, near Pottsville, which are down 1600 feet, the best drilling was 79 feet in 12 hours, and the best blasting 80 feet per month.

The steel-pointed or "percussion" drills are extensively used in sinking, driving, and all kinds of drilling in mines, and for quarry and railroad work. For surface work they are mounted on tripods, for shafting or tunneling on bars or columns securely fastened against the sides or top and bottom of the work, or are mounted on wagons adapted for the purpose.

In the following results, claimed to have been attained by the different drills, it should be remembered that they cannot be accepted as evidence of superiority over each other, because we do not know that the pressure of compressed air or steam used, the character of the rock, and all the circumstances attending the trials, were the same in all cases.

The Ingersoll "Eclipse" Rock Drills are made of six sizes. They are made to drill holes from three-quarters of an inch to six inches in diameter. In the tunnel under West Point, size 24 feet by 26 feet, in trap rock, these drills are used, and a progress of 139 feet was made in one month, although four shifts were lost for holidays. In a drift 4 by 6 feet in the Comstock, Nevada, through moderately hard porphyry, with one of these drills, a progress of 160 feet per month was made. Outside of the Comstock 100 feet is claimed as a fair progress for two drills. A saving of 50 per cent. over hand drilling is claimed. There are over 3,000 of these drills in use, and they are giving excellent satisfaction wherever employed.

The Burleigh Rock Drill is made in seven sizes, ranging in weight from 220 to 1000 pounds, and to drill holes from 1 to 5 inches in diameter. With the Stoper drill of this

make a hole 1¼ inch diameter, 13½ inches deep was bored in *one minute*, 70 lbs. steam. Rock, hard granite. In a conglomerate rock, from Dakota, so hard as to cut glass, a hole 5½ inches in depth was made in five minutes. In the harbor of New York (Hell Gate) a 120 foot hole was made in a day. At the Sutro tunnel, Nevada, with these drills, a progress of 350 feet to 400 feet per month in an 8-foot by 10-foot heading was made. A saving of 50 per cent. over hand labor is claimed.

The Rand Little Giant Rock Drill is made in six sizes, ranging in weight from 150 to 900 pounds, and to drill holes from ½ inch to 4 inches in diameter. It is claimed for this make of drills that as much progress can be made with them as with any other, and at as proportionally great saving over hand drilling.

The Bryer Rock Drill is made in five sizes, ranging in weight from 150 to 400 pounds, and to drill holes from 1½ to 4 inches in diameter. This drill has, in hard granite, drilled a 2-inch hole 2½ inches per minute; in amygdaloid, 8 feet per hour; and in slate 4 inches per minute.

The National Rock Drill is made in five sizes, ranging in weight from 150 to 600 pounds, and to drill holes from 1¾ inches to 3½ inches in diameter. With this drill, in the Perkiomen Tunnel, a saving of two-thirds on hand drilling was claimed.

The Johnson Rock Drill. With this drill a hole 4 inches deep has been put in Quincy granite in 1 minute, and 11 inches in 4 minutes. In Vermont marble a 1½ inch bit penetrated 9 inches in 4 minutes. At the Duncan mine, in 16 hours, the Johnson Drill has penetrated 60 feet in mixed rock, diorite, quartz, mundic, &c.

HAULAGE.

There has been but little experience in this country with the various systems of haulage, such as endless chain, tail-rope, &c., that are employed in Great Britain to cheapen the cost of the inside movement of coal. The mine locomotives lately introduced here, however, are much more economical than mule power, and, if it were not for the deleterious gases they generate, would be used wherever the size of the openings would permit and the length of the hauls make them advantageous.

Carbonic oxide gas is a result of combustion, and is produced by the mine locomotive It is very destructive to animal life, and some very serious accidents have already been traced to it where it has been generated in this way. Mine locomotives should only be used in gangways that are return airways, as in no case should men be compelled to breathe air which has been fouled by a locomotive.

SHAFTING AND TUNNELING.

The cost of shafting and tunneling, of course, varies with the strata. A shaft through conglomerate, such as overlies the Mammoth vein in the Anthracite Region, 15 by 25 feet in area, will cost about $200 per yard. Through the same strata, a tunnel 8 by 9 feet can be driven, with the use of the present explosives, for $50 per yard. Slopes timbered with bottom and top sills 20 feet long, legs 14 feet high, with timber 5 feet from centre to centre, can be sunk in the anthracite region, if there is not too much water, for about $40 per yard.

PROPORTION OF PILLARS TO OPENINGS.

In the following table, the weight thrown upon pillars at different depths by the removal of different proportions of coal is given.

Depth of seam in feet	Weight on Pillars, the proportion to mine got being								
	90 per cent. Lbs. per sq. in.	80 per cent. Lbs. per sq. in.	70 per cent. Lbs. per sq. in.	60 per cent. Lbs. per sq.in.	50 per cent. Lbs. per sq.in.	40 per cent. Lbs. per sq.in.	30 per cent. Lbs. per sq.in.	20 per cent. Lbs. per sq.in.	10 per cent. Lbs. per sq. in.
100	111	125	142	166	200	250	333	500	1,000
500	555	625	710	830	1,000	1,250	1,665	2,500	5,000
1,000	1,111	1,250	1,428	1,666	2,000	2,500	3,333	5,000	10,000
1,500	1,666	1,875	2,138	2,496	3,000	3,750	4,998	7,500	15,000
2,000	2,222	2,500	2,956	3,333	4,000	5,000	6,666	.....	.....
3,000	3,333	3,750	4,384	4,999	6,000	7,500	.....	.....	.....
4,000	4,444	5,000	5,912	6,666	8,000	.....	.....	.....	.....
5,000	5,555	6,250	7,340	.....	.....	.....	.....	.....	.....
10,000	11,111	12,500	.....	.....	.....	.....	.....	.....	.....

In his "Winning and Working of Collieries," Mr. Dunn, of England, gives the following scale for first working, with the design of afterwards taking out the pillars, the width of the principal workings being 5 yards, and cross holings 2 yards. This will apply to bituminous workings only.

Fathoms deep.	Size of pillars in yards.	Proportion in pillars.	Fathoms deep.	Size of pillars in yards.	Proportion in pillars.
20	20 by 5	.41	180	26 by 14	.69
40	20 " 6	.50	200	26 " 16	.71
60	22 " 7	.52	220	18 " 18	.73
80	22 " 8	.57	240	28 " 20	.75
100	22 " 9	.59	260	30 " 21	.77
120	22 "12	.61	280	30 " 22½	.78
140	26 "15	.63	300	30 " 24	.79
160	28 "16	.66	M. Wear-mouth, 40	" 29	.80

VENTILATION.

The quantity of air necessary to ensure sufficient ventilation in a mine has been variously estimated by the following authorities :

Mr. Herbert Mackworth : A minimum of 100 cubic feet per minute for each man and boy, for sanitary purposes alone, where there is no escape of fire-damp, and little of any other mineral gas.

Mr. Hedley : From 100 to 500 cubic feet per minute for each collier.

Mr. J. K. Blackwell : From 250 to 500 cubic feet per minute for each collier.

Mr. Matthias Dunn : The minimum quantity of fresh air for the most harmless of pits, ought to be from 10,000 to 15,000 cubic feet per minute.

Mr. T. J. Taylor : In a mine yielding no fire-damp, with from 120 to 130 persons employed, a current of 20,000 to 30,000 feet per minute, properly conveyed up to the face of the workings, and made to sweep the districts in which the people are employed. In fiery mines a much greater quantity.

Mr. Warrington W. Smyth : In round numbers 100 cubic feet of air per minute may be required for the health and comfort of each person underground ; but if fire-damp be given off, say at the rate of 200 cubic feet per minute, we should need, at the very least, thirty times that amount of fresh air to dilute it, or 6000 cubic feet in addition.

Professor Phillips : In most of the fiery mines an average of 600 cubic feet per minute per collier is circulated ; and nearly 200 cubic feet per minute for each acre of waste.

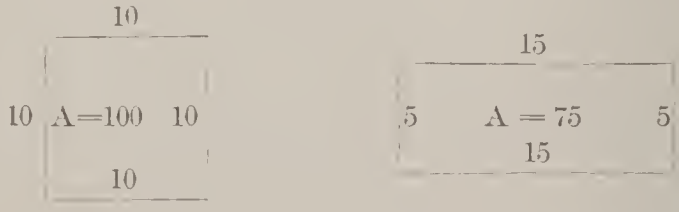
For all anthracite mines nearly double the above estimates should be allowed, because of the much greater volume of powder smoke due to the large amount of blasting that is done.

The Mine Ventilation Act for the Anthracite Region of Pennsylvania provides for 66 cubic feet of pure air per minute for each man working. All authorities agree in declaring this amount inadequate.

FRICTION OF AIR IN MINES.

In speaking of ventilation, it must be remembered that air is like all other material bodies. When it is at rest, it takes pressure or power to move it, and when it is once in motion, it would keep in motion if it was not for friction acting on it like a brake. Air rubbing against the sides of the mine is affected the same as a sled rubbing against the ground. In thus rubbing against the sides of a mine air is governed by certain laws. The following is a plain manner in which to present these laws or principles.

The resistance increases with the length it has to run. To illustrate this principle, take a fan-pipe 12 by 12 inches square; then get a log of timber 11 by 11 inches square and 6 feet long; put it in the pipe and attach a steelyard to it. We find that it takes a pound of power to move it. If we now take a piece of timber of the same size 12 feet long, and place it in the pipe, we will find that it takes double the amount of power to move it. If the timber were three times as long, it would take three times the power, &c., so long as the velocity or speed continued the same. Air is controlled by the same law, because if we double or treble the length of the air column, we double or treble the weight to be moved and the surface to be moved over, and therefore double or treble the resistance and power.



Take the two airways outlined above. The area of the one is three-fourths of the other, for one is 100 and the other is 75, but the perimeter or rubbing surface is = for = lengths. If we employed one pound on the square foot of the 100-foot airway to put a given quantity of air into circulation, and want to put the same power on the 75-foot airway, we would have to put on $1\frac{1}{3}$ pounds to the square foot to overcome the same rubbing surface, the velocity in both being equal; because both airways have the same rubbing surface for the same length, it will take the same total pressure to maintain the same velocity. To obtain the same total pressure on the 75 as upon the

100, we must have for one on the 100-foot airway one and one-third on the 75-foot airway; so we require one-third more pressure on the foot of the small one than we do on the large one to secure the same speed. Again, at the same speed or velocity, the one would give say 12,000 cubic feet of air, and the other 9,000 feet, so that one and one-third pounds pressure on the small airway only gives three-fourths of what one pound of pressure gives on the large one.

The resistance in the same airway varies, that is, increases or decreases in the same proportion that the square of the velocity increases or decreases. If we double our speed or quantity of air, we have to put four times the pressure on each square foot, because if we put twice as much through as we did before, we make a column twice the length rub against the airway in a given time. This will require a double pressure, and this double column is also made to strike these resistances with a double momentum or shock or force. Again, the double meeting of the resistance being doubled by the double momentum or force, makes four times the resistance for double the quantity of air. Again, if we want four times the quantity of air, we want four times the speed, and get four times the length of column to rub against our airway in a minute or second, and each length of the four striking with four times the force, makes 4×4 or 16 times the resistance, and, of course, would need 16 times the pressure per square foot to overcome it.

The quantity of air varies as the square of the pressure, and as the cube of the power.

Example.

Suppose 30,000 feet of air per minute is obtained by a 20-horse power engine. To double the quantity of air would require a 160-horse power engine, or

$$2 \times 2 \times 2 = 8,$$
$$\text{and } 20 \times 8 = 160,$$

or the cube of the power.

To treble the quantity of air would require

$$3 \times 3 \times 3 = 27,$$
$$\text{and } 20 \times 27 = 540,$$

or the cube of the power.

On this subject the following data have been given by Mr. J. J. Atkinson:

The pressure required to overcome the friction of air increases and decreases in exactly the same proportion that the area or extent of the rubbing surface exposed to the air increases or decreases; so that when the velocity of the air and the sectional area of the air-way remain the same, the pressure required to overcome the friction is proportioned to the area and extent of the rubbing surface exposed to it. The rubbing surface depends on the perimeter of the air-way, and upon its length.

The friction of air or gas in passing through the same pipe or air-way varies as the density of the gas or air varies; but in the air-ways of coal mines the air has always nearly one and the same density.

The pressures employed to ventilate mines are commonly reckoned at so much per square foot of area, and not by the entire pressure employed, which is equal to the area in square feet $\times$ the pressure per square foot of sectional area of air-way.

The pressure required to overcome the friction in the same air-way varies in the same proportion that the square of the velocity of the air varies, increasing or decreasing accordingly.

It seems probable that for every foot of rubbing surface, and for a velocity in the air of 1000 feet per minute, the friction is equal to 0·26881 ft. of air column of the same density as the flowing air, which is equal to a pressure, with air at 32 degrees, of 0·0217 lbs. per square foot of area of section. Calling this the co-efficient of friction, we have the following rules with respect to the friction of air in mines moving along level passages of the same area.

Let a = size of airway in square feet.
" h = horse-power of ventilation.
" k = co-efficient of friction.
" l = length of airway or channel.
" o = perimeter of airway or channel.
" p = pressure in pounds per square foot of section.
" q = quantity of air circulating in cubic feet per minute.
" s = area in square feet of rubbing surface exposed to current.
" u = units of work, foot, pounds or power, applied to circulate air.
" v = velocity of the air in feet per minute.
" w = water gauge in inches.

The co-efficient (k) can be used as follows: .0217 pounds per square foot of area for every square foot of rubbing surface exposed to the air current at a velocity of 1,000 lineal feet per minute, or .0000000217 pounds for a velocity of one foot per minute or $\frac{1}{46082930}$.

Formula:

1. $a = \frac{k\,s\,v^2}{p} = \frac{p\,a}{p} = \frac{k\,s\,v^2\,q}{u} = \frac{k\,s\,v^3}{p\,v} = \frac{u}{p\,v} = \frac{q}{v} = \sqrt[3]{\frac{q}{\frac{u}{k\,s}}}$

2. $h = \frac{u}{33000} = \frac{q\,p}{33000}$

3. $k = \frac{p\,a}{s\,v^2} = \frac{u}{s\,v^3} = \frac{p}{\frac{s\,v^2}{a}} = \frac{w\,5\frac{1}{5}}{\frac{s\,v^2}{a}}$

4. $o = \frac{s}{l}$

5. $p = \frac{k\,s\,v^2}{a} = \frac{u}{q} = \frac{p\,a}{a} = \frac{k\,s\,v^3}{q} = \frac{u}{a\,v} = 5.2\,w.$

6. $p\,a = k\,s\,v^2 = \left(\sqrt[3]{\frac{u}{k\,s}}\right)^2 k\,s = \frac{u}{v}$

7. $q = v\,a = \frac{u}{p} = \frac{k\,s\,v^3}{p} = \sqrt{\frac{p\,a}{k\,s}}\,a = \sqrt[3]{\frac{u}{k\,s}}\,a$

8. $s = \frac{p\,a}{k\,v^2} = \frac{u}{k\,v^3} = \frac{q\,p}{k\,v^3} = \frac{v\,p\,a}{k\,v^3} = l\,o$

9. $u = q\,p = v\,p\,a = \frac{k\,s\,v^2\,q}{a} = k\,s\,v^3 = q\,5.2\,w = h\,33000$

10. $v = \frac{u}{p\,a} = \frac{q}{a} = \sqrt[3]{\frac{u}{k\,s}} = \sqrt[3]{\frac{q\,p}{k\,s}}\,\sqrt[2]{\frac{p\,a}{k\,s}}$

11. $v^2 = \frac{p\,a}{k\,s} = \left(\sqrt[3]{\frac{u}{k\,s}}\right)^2$

12. $v^3 = \frac{u}{k\,s} = \frac{q\,p}{k\,s} = \frac{v\,p\,a}{k\,s}$

13. $w = \frac{\frac{k\,s\,v^2}{a}}{5.2} = \frac{p}{5\,2}$

These formula comprise the pressure referrable to the resistence offered by the mine, but not that necessary to produce velocity; therefore they are more correct for long than short passages. The pressure required for the final velocity becomes a smaller fraction of the whole drag as the airways are extended. If it is required to take into account the pressure required to create velocity, instead of using p, use $p - p\,v$; $p\,v$ being the pressure required to produce the final velocity. In this case

Instead of using $a = \frac{k\,s\,v^2}{p}$ substitue $\frac{k\,s\,v^2}{p-P}$

" " $p\,a = k\,s\,v^2$ " $a\,(p-P) = k\,s\,v^2$

" " $p = \frac{k\,s\,v^2}{a}$ " $p - P = \frac{k\,s\,v}{a}$ or

$$[p = \frac{k\,s\,v^2}{a} + P$$

" " $s = \frac{p\,a}{k\,v^2}$ substitute $\frac{(p-P)\,a}{k\,v^2}$

" " $v = \sqrt{\frac{p\,a}{k\,s}}$ " $\sqrt[2]{\frac{(p-P)\,a}{k\,s}}$

The co-efficient varies with the nature of the rubbing surface, and consequently may be different in the different air-passages of the same mine. The following plan may be adopted for ascertaining the friction of air in a passage. Place a gutta-percha tube of small section along the portion of the gallery the friction of which it is desired to know; close the end of the tube fixed opposite to the current, and place a water-guage on the closure, and the instrument will then show the difference of pressure at the two extremities of the tube. Then the water-gauge multiplied by $5.2 = p$ in pounds.

FURNACE VENTILATION.

The power obtained by furnace ventilation depends upon the depth of the upcast, and the difference of temperature between it and the downcast. The weight of a cubic foot of air is found as follows:

$$w = \frac{1.32529\ B}{459 + t.}$$

The *motive column* is the length of a column of air in the upcast, the weight of which is equal to the difference of the weight in the two shafts; and if by t and t_2 is represented the temperatures of the downcast and upcast shafts respectively, then the motive column =

$$\text{Depth of upcast} \times \frac{t_2 - t_1}{459 + t_1}.$$

All other things being equal the amount of ventilation depends on the square root of the depth of the shaft.

MECHANICAL VENTILATION.

The *Guibal* fan is more popular in England than any other, there being over 200 of these machines at present working. At Pemberton, England, there is a fan of this description 46 feet diameter and 15 feet wide, producing a ventilation of 200,000 feet with three inches of water-gauge. These fans are also very popular in this country, and Messrs. Coxe & Co., of Drifton, Luzerne county, have incased several which they have recently erected with strong wrought iron casing, so that if any part of the machinery gets on fire from the journals overheating, there will be no danger of the structure burning down, as has been the case with fans incased in wood.

The *Waddle* Ventilating Fan stands next in favor in the old country; it is, like the Guibal, a centrifugal machine, but not being so wide has to run at a great velocity.

Cooke's Ventilator is a displacement machine, consisting of eccentric cylindrical drums and shutters, which seal the outlet while the air is being drawn from the mine. According to experiments recorded in a paper on "Mechanical Ventilation," by Mr. W. Daniel, M. Inst. M. E., of England, the useful effect of two machines varied from 58½ to 64 per cent. of the indicated horse-power of the engines. If indicator diagrams had been taken, showing the loss on the engine due to friction, the useful effect must have been more.

Root's Ventilator is a displacement machine. According to Mr. E. Hamer Carbutt, Vice-President, Inst. M. E., of England, the useful effect is given at 51.40 to 76.85 per cent.

The *Lemielle* Fan is a displacement machine placed in a chamber of masonry, communicating on one side with the upcast shaft, and on the other with the external atmosphere. In this chamber a drum revolves, which is placed eccentrically; at equal distances three vertical shutters are hinged to the drum, the outer edges of which are kept close to the walls of the chambers by the rods which radiate from, and revolve at their centres, upon, the fixed shaft.

The *Champion* Ventilator, patented by F. Murphy, C. E., of Streetor, Ill., is a centrifugal machine. A double fan working on one shaft is used, and the casing is so arranged that it can be converted from an exhauster to a blower, or *vice versa*, without stopping or changing the motion of the fans. The case consists of three vertical, box-like compartments. The two side compartments are of equal size, and are narrower than the central one, which is a receiving chamber through which all the air passes on its way to the fans. The two side compartments contain the fans and are so arranged that the air can be led either into the open air or down the mine-shaft at will. A 4½-foot fan of this make at Springbrooke colliery, Yorktown, will exhaust about 25,000 cubic feet per minute, running at 400 revolutions; water gauge ½-inch.

The following table, from the French of M. Ponson, gives the results of a series of experiments with various mechanical ventilators:

Description of Ventilator.	Name of Colliery.	Average.			Maximum.		Ratio of Actual and Theoretical Volumes.	Velocity of issue of air in feet per minute.	Ratio of the Power to the Resistances produced.			Power given out (F) in H. P.	Ratio of (E) to (F).
		Volumes in cubic feet per minute.	Water Gauge in inches.	Useful Effect (E) H. P.	Volumes in cubic feet per minute.	Water Gauge in inches.			By friction in the pipes.	By the exhaustion.	By the velocity of issue.		
RECIPROCATING AIR PUMPS:													
Piston Machine	Esperance	17,000	1.64	4.80	17,000	1.64	92	7,872	.....	.....	.....	20.99	23
Devaux	Marihaye	.....	1.60	3.65	.....	1.60	92	4,416	.....	.....	.....	7.60	48
Mahaut	Monteeau Fontaine	29,135	3.93	18.01	29,135	3.93	76	.....	.....	.....	.....	27.10	66
Nixon	Lower Duffryn	92,700	3.00	43.70	92,700	3.00	91	.....	.....	.....	.....	112.00	39
Struvé	Risca	43,866	2.31	15.94	43,866	2.31	89	.....	.....	.....	.....	41.50	38
"	Cwm Avon	53,920	2.92	24.95	57,250	3.50	94	.....	.....	.....	.....	58.79	42
CENTRIFUGAL FANS:													
Combes (curved vanes)	Grand Hornu	6,800	1.05	1.06	9,682	1.49	...	4,764	.380	.....	.220	5.30	20
Letoret (flat vanes)	Bayemont	12,350	2.00	4.55	14,670	2.28	...	6,928	.170	.....	.403	17.28	26
"	Bois D'Epinois	14,340	1.57	3.56	14,340	1.57	...	6,793	.174	.....	.390	14.58	24
Rammell	Framwellgate Moor	53,600	2.15	18.40	53,600	2.15	...	.....	.....	.....	.....	46.00	40
Guibal	St. Placide	32,780	1.88	12.00	50,250	3.35	...	.....	.....	.....	.....	24.46	45
"	Staveley	108,670	2.55	44.06	114,675	3.00	...	.....	.....	.....	.....	75.24	58
"	Pelton	84,000	2.41	33.64	94,809	2.87	...	.....	.....	.....	.....	70.66	47
Waddle	"	98,612	2.51	39.55	101,169	2.65	...	.....	.....	.....	.....	98.84	40
"	High Park	90,060	2.19	34.12	114,360	3.56	...	.....	.....	.....	.....	62.96	54
ARCHIMEDIAN SCREWS:													
Motte	Sauwartan	8,620	0.97	1.24	8,960	1.00	...	.....	.....	.....	.....	5.00	25
"	Tricukaizin	13,690	0.83	1.78	13,690	1.78	...	.....	.....	.....	.....	7.59	23
Pasquet	Reunion	18,810	1.18	3.51	18,810	1.18	52	3,876	.....	.402	.....	12.87	27
"	Vivier	11,400	1.18	2.12	11,400	1.18	50	3,076	.....	.317	.....	7.69	27
Lesoinne	Grand Bac	16,950	0.197	0.52	18,000	0.197	70	.....	.....	.....	.....	2.03	25
"	Val Benoit	21,600	0.41	1.36	21,600	0.41	63	.....	.....	.....	.....	5.94	24
ROTARY PUMPS:													
Fabry (3 teeth)	Gouffre	19,900	1.50	4.65	21,500	2.09	74	.....	.....	.....	.....	8.60	54
" (2 teeth)	Aiseau	28,295	1.27	5.66	28,390	1.65	86	.....	.....	.....	.....	11.40	50
" "	Louviere	22,780	3.55	12.86	25,230	4.33	71	.....	.....	.....	.....	25.75	50
Lemielle	Belle et Bonne	15,000	3.22	7.91	17,230	4.06	...	.....	.....	.....	.....	16.81	47
"	Bois du Boussu	60,700	3.00	28.20	95,850	5.91	...	.....	.....	.....	.....	125.80	38
"	Page Bank	85,900	3.25	48.08	134,100	6.65	63	.....	.....	.....	.....	129.75	37

MEASUREMENT OF VENTILATION.

Three methods have been employed for the purpose of ascertaining the velocities of the currents and the quantities of air circulating in mines. They are fully described in a paper by Messrs. Atkinson and Daglish, read at the Birmingham Meeting of the North of England Institute of Mining Engineers, 1861. They are :

1. *Traveling at the same velocity as the current and noting the distance passed over in a unit of time.*—This was a very primitive mode, but no doubt when used it gave a fair approximation to the truth ; for recent experiments have proved that it admitted of great accuracy for velocities up to 400 feet per minute. It was open to many objections, and would be utterly unsuited to the large mines now existing, since it would be impossible to walk as quickly as the currents travel in the principal splits, and running is not a sufficiently steady pace for the purpose. The process was as follows : Choice was made of a part of the gallery forming the airway, having as uniform sectional dimensions as could be found, and, after measuring off a distance of a hundred or a hundred and fifty yards in length, the operator took a lighted candle, and walked in the direction of the current, fully exposing the flame to its influence, but taking care to move at such a rate that the flame would burn in an upright position without being deflected from the vertical either by the current or by the progress of the person carrying it. The time required to traverse the distance measured off being carefully noted by a seconds' watch, the average rate of walking was thereby determined, and three or four trials served to give the assumed velocity of the air-current. This, multiplied by the average sectional area of the part of the airway selected for experiment, was taken to represent the quantity of air passing in the unit of time.

2. *Determining from observation the rate at which small floating particles are carried along by the current, and assuming their velocities to be identical with that of the air-current itself.*

Until recently, observations of the velocity of the smoke from an exploded charge of gunpowder, in a part of the gallery of nearly uniform sectional area, were the means

most generally adopted in the coal mines of this country for ascertaining the velocity of air-currents. They are still considerably used, and, so far as regards shaft velocities, they remain the only method. For this purpose an even part of the road should be selected, about 50 to 60 feet in length, and its cubical contents in feet ascertained. Then let off a flash of gunpowder at the windward end of the channel, and observe the number of seconds the smoke is in passing to the other end. Then say, as the time (in seconds) in passing is to the cubic area, so is 60 seconds to the number of cubic feet passing per minute.

EXAMPLE: Length of channel selected, 60 feet; height, $5\frac{1}{2}$ feet; width 6 feet; time in passing, 4 seconds. What is the amount of air?

$$60 \times 5\tfrac{1}{2} \times 6 = 1980 \text{ cubic area; and}$$

$$\text{As } 4 : 1980 :: 60 : 29{,}700 \text{ cubic feet per minute.}$$

Messrs. Atkinson and Daglish have shown by experiments that this process is subject to various sources of error, viz:

CAUSE.	EFFECT.
(1). The expansion of the whole column of air, by the addition to it of the results of the combustion of gunpowder, and by the heat developed (of slight magnitude).	Tending to INCREASE apparent velocity owing to two causes, viz:— (1). The conversion of a small portion of solid gunpowder into gas. (2). The further expansion of this owing to the high temperature of ignition.
(2). The explosive force of gunpowder (of considerable magnitude).	Tending to INCREASE the apparent velocity, and can be avoided with care.
(3). Diffusion or deposition of the smoke.	Tending to DECREASE very considerably the apparent velocity.
(4). Eddies and currents. (5). The density of the smoke.	Giving rise to serious irregularities, materially affecting the accuracy of the results.

By the use of fixed quantities and distances, and the avoidance of extreme velocities, an approximation to accuracy may be obtained. To secure this, the following precautions are recommended:

(*a*). Always to use one cubic inch of gunpowder as a standard.

(*b*). The velocity of the current never to be less than 100 feet per minute, nor to exceed 500 feet per minute. In order to attain this, a gallery of such area must be selected as will afford this velocity of current.

(*c*). The time not to be less than 12 seconds, nor to exceed 30 seconds.

(*d*). To explode the gunpowder ten feet to the windward of the first mark.

Therefore, in slow currents of from 100 to 250 feet per minute velocity, the distance to be taken over which the smoke passes will be 50 feet; and for the higher velocicities, of from 250 to 500 feet, the distance will be increased to 100 feet.

3. *By using the Anemometer.*—This apparatus is of various forms and may be divided into three classes.

(*a*). Those having vanes or wands made to *revolve* by the current of air impinging upon them, the rate at which they revolve being indicated by pointers on dials forming a part of the instrument. They include Combe's, Biram's, Whewel's, Osler's and Robinson's.

(*b*). Instruments which are affected by the force or impulse of the wind, without being subjected to any continuous revolving motion. These include Dr. Lind's, Henaut's, Bougier's and Dickinson's anemometers.

(*c*). Those of a more complex character, such as Leslie's.

Biram's anemometer is in general use in this country. Each revolution of the vanes, which is registered on the dial plate, corresponds to one foot in the linear motion of the air. Then if we multiply the velocity per minute by the sectional area of the channel in which the anemometer is placed, we have the number of cubic feet of air passing per minute.

The following is a table of experiments made by Inspector T. D. Jones, of the South District of Luzerne and Carbon counties, in No. 3 slope, Nesquehoning, for the purpose of showing the comparative degrees of accuracy of the three modes of measuring air-currents above described. The anemometer used was a Biram.

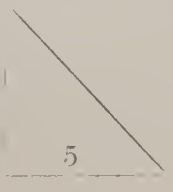
	Gunpowder Smoke.			Walking.		Anemometer used	
	Equal distance.		Equal times.	Equal distances.		Biram.	
	50 Ft.	200 Ft.	20 Sec.	50 Ft.	200 Ft.	R S.	True velocities calculated by formula $V = 97\ r + 40$.
	A B.	C D.	E F.	K L.	M N.		
1	Feet a min.	Feet a min.	Feet a min.	Feet a min.	Feet a min.	Revol. a min.	Feet a min.
2.....	136	143	132	158	158	82	139
3.....	158	156	150	171	169	110	166
4.....	160	156	156	143	174	113	169
5.....	207	177	186	193	203	155	210
6.....	200	207	.....	193	202	157	212
7.....	214	224	.....	222	230	165	220
8.....	231	245	.....	231	249	200	254
.....	231	232	.....	231	251	197	251
Ave..	192	192	.....	193	204	.....	203

In calculating the velocities in the table in feet per minute, the fractional part of a foot was disregarded when it did not exceed one-half of a foot lineal.

To measure air-currents correctly with the anemometer, we should take a straight passage for measurement, as at a curve the current goes to the outside of the circle. Take it on both sides near the top and bottom. Add together the different results, and divide them by the number of measurements, and the result will be the average velocity of the current.

Examples.

Suppose we want to measure an airway of the following shape :



We find the height six feet and the bottom five feet; then $6 \times 2\frac{1}{2}$ or $6 \times 2.5 = 15.0$ feet. Suppose we find the velocity on the anemometer to be 300 feet per minute; then $15 \times 300 = 4500$ feet of air per minute, or more correctly, $\frac{300 \times .96}{100} = 288 + 40 \times 15 = 4920$, which is the rule given by Biram for his anemometer.

Suppose we have a 10-horse power forcing-fan delivering 20,000 cubic feet per minute at the inside end of a monkey gangway when the latter is 800 yards from the fan, and suppose we drive on the monkey till it is 1300 yards from the fan, and we want to get 20,000 cubic feet to that point. How much more power will be required?

800 : 10 :: 1300 : 16·25 and 16·25 10=6¼ H P more.

TO FIND THE AREA OF DIFFERENT FORMS OF AIRWAYS.

base × height = area.

½ base × height = area.

½ sum of two parallel sides × height = area.

diameter × 3.1416 = circumference.

$\frac{\text{circumference}}{3.1416}$ = diameter.

diameter ^{2} × .7854 = area.

side of = square = diameter × .8862.

Formula for determining the quantity of air by the thermometer:—Temperature of air (t) on the outside of current being very accurately taken, raise the temperature of the thermometer 10° above t, and then observe the number of seconds s which elapse while the thermometer exposed to the free current of air cools to 5° of the 10°, then

$$\frac{c}{s^2} = \text{feet per second velocity,}$$

c being a constant peculiar to the instrument; in one case, for example, it was 16,000. Let the bulb be very clear.

The Water-Gauge is used to ascertain the "drag" or resistance to the air in a mine. The resistance is found by taking the difference of density between the *in-take* and *return* air. This may be done by placing the water-gauge through a door erected in a passage connecting the road along which the fresh air is entering the mine and the road by which the foul air is returning. The glass tube being open at each extremity, the difference of the water-level in the two branches of the tube represents the difference of density of the intake and return air. The weight of a square foot of water one inch deep equals 5.2 lbs.; therefore, for every inch there is in difference between the two branches of the tube there will be 5.2 lbs. of "drag" or resistance to each square foot of the airway; and to find the horse-power of the ventilation, multiply the quantity of air passing per minute by the "drag," and again by 5.2, and divide by 33,000.

Example.

What is the horse-power expended when the ventilating current measures 30,000 cubic feet per minute, and the water-gauge is 0.65?

$$\frac{30{,}000 \times 0.65 \times 5.2}{33{,}000} = 3.07 \text{ H. P.}$$

NOTE ON THE WATER-GAUGE AND THE QUANTITY OF AIR CIRCULATING.

The quantity of air passing in a mine is according to the square root of the water-gauge, which is the measure of the pressure of the ventilation in force. The following figures give the square root of the water-gauge for every one-tenth of an inch from half an inch to three inches, and the quantity of air that will pass for each height of the water-gauge, supposing 10,000 cubic feet pass when it stands at one inch, the air-courses remaining in the same condition :

W. G.	Square root of W. G.	Quantity.	W. G.	Square root of W. G.	Quantity.
.5	.7071	7,071	1.8	1.3416	13,416
.6	.7745	7,745	1.9	1.3784	13,784
.7	.8366	8,366	2.	1.4142	14,142
.8	.8944	8,944	2 1	1.4491	14,491
.9	.9486	9,486	2.2	1.4832	14,832
1.	1.	10,000	2.3	1.5165	15,165
1.1	1.0488	10,488	2.4	1.5491	15,491
1.2	1.0954	10,954	2.5	1.5811	15,811
1.3	1.1401	11,401	2.6	1.6144	16,124
1.4	1.1832	11,832	2.7	1.6431	16,431
1.5	1.2247	12,247	2.8	1.6733	16,733
1.6	1.2649	12,649	2.9	1.7029	17,029
1.7	1.3038	13,038	3.0	1.7320	17,320

If it be required to know the quantity that will pass under other circumstances it may be found by rule of three. Thus, supposing 20,000 feet of air pass with a water-gauge of $1\frac{1}{2}$ inches, what quantity will circulate with $2\frac{1}{2}$ inches of water-gauge? The square root of $1\frac{1}{2} = 1.2247$ and of $2\frac{1}{2} = 1.5811$, then we say:

As 1.2247 : 20000 : : 1.5811 : 25820, the quantity required.

GASES MET WITH IN MINES.

ATMOSPHERIC AIR.

Air is a mixture of two gases, oxygen and nitrogen, with a trace of carbonic acid forming about five volumes in 1000 of the atmosphere, and more or less of watery vapor diffused through the gases of which it is composed,

but not considered as forming a constituent part, and not embraced in statements as to the chemical composition of air.

Dry air is composed of--

	By weight.	By volume.
Nitrogen	77 per cent.	79 per cent.
Oxygen	23 "	21 "
	100	100

A cubic foot of air, at the temperature of melting ice (32°) and under pressure of 14.7 pounds per square inch, or $144 \times 14.7 = 2116.8$ pounds per square foot, weighs 0.080728 pounds, so that under the same conditions 1000 cubic feet weigh 80.728 pounds avoirdupois.

NITROGEN GAS.

Nitrogen gas is lighter than air under the same temperature and pressure. The specific gravity of air being taken as 1000, that of nitrogen is 971.37, so that 1000 cubic feet of air weighs 80.728 pounds, and 1000 cubic feet of nitrogen 78.416 pounds, and one foot of air weighs 0.080728 pounds at 32° and 14.7 pounds pressure per square inch, one foot of nitrogen, under same conditions, weighs 1.0784167 pounds. Nitrogen gas has neither color, taste nor smell, will not support life nor combustion, but destroys life and extinguishes lights. Its use is to dilate the oxygen of the atmosphere, and render it fit for respiration.

OXYGEN GAS.

Oxygen forms 21 per cent. by volume, and 23 per cent. by weight, or more than one-fifth of atmospheric air. Its specific gravity is 1105.63, that of air being 1000 at a temperature of 32° and pressure of 14.7 pounds per square inch, 1000 feet weighs 89.255 pounds; air, same conditions, 80.728 pounds. Oxygen has neither color, taste nor smell; red-hot wire will burn brilliantly in it, and animals die through excess of vital action.

CARBONIC ACID GAS--BLACK DAMP.

This gas is composed of oxygen and carbon. Its chemical composition is:

	By atoms.	By weight.	By volume.
Oxygen	2	72.73 per ct.	1
Carbon	1	27.27 "	1
	1	100.00	1 condensed.

Carbonic acid gas is a poisonous mixture, although it contains nearly 3 out of 4 by weight of oxygen (the life-supporting element). It is dangerous to life to breathe air containing from 10 to 12 per cent. According to Frieberg, conditions can exist when miners will be struck down before the light is extinguished, although lights will not burn in air mixed with one-tenth of it. The breathing of this gas acts like a narcotic poison; first exciting, then producing paralysis, and at last, by satiety, death. It is, therefore, similar to chloroform. Its specific gravity is 1528.01, that of air being 1000. At a temperature of 32° and pressure of 14.7 pounds per square inch, 1000 cubic feet of carbonic acid gas weighs 123.353 pounds. Air, same conditions, 80.728. As it is rather more than one and one-half times as heavy as common air, it is always found on the lowest levels of mines, or next the floor, except where displaced by currents or expanded by heat.

It is called by the miners "black damp," "stythe," "choke-damp," &c. It is frequently met with; in fact, it is not absent in any mine where the air is not continually renewed. It is produced in all collieries by the breath of the workmen (each man exhales 6.3 gallons of this gas hourly), the burning of lights, the explosion of powder, the fermentation of animal and vegetable substances, &c.

HYDROGEN GAS.

Hydrogen has neither color, taste nor smell, and is not a supporter of combustion. If a light be plunged into a jar of it, it is extinguished. When mixed with common air or pure oxygen, it is highly explosive. Its specific gravity is 0.06927, air being 1. It is the lightest of all the gases.

CARBURETED HYDROGEN GAS.

Carbureted hydrogen gas is chemically composed of:

	By atoms.	By weight.	By volume.
Hydrogen.....	2	24.6 per ct.	2
Carbon.....	1	75.4 "	1
	1	100.0 "	1 condensed.

At a temperature of 32°, and under pressure of 14.7 pounds per square inch, 1000 cubic feet of it weighs 45.368 pounds. Air, same conditions, 80.728 pounds; so that it is rather more than one-half as heavy as an equal volume of air under the same conditions.

FIRE-DAMP.

Fire-damp is not, as commonly supposed, identical with carbureted hydrogen gas, as will appear from the following analysis:

	Jarrow, Bensham Seam. (Playfair.)	Killingworth. (Richardson.)	Gateshead. (Graham.)
Carbureted hydrogen...	83.10	66.30	94.20
Light air.....	.....	23.35	.....
Nitrogen.....	14.20	6.52	4.50
Oxygen.....	0.40	.....	1.30
Carbonic acid.....	2.10	4.03	.....

Its specific gravity is 0.650. Owing to the fact that it is lighter than air, it is always found at the lowest level in mines, if not disturbed by currents; if left still, it will mix by diffusion with the surrounding atmosphere. The breathing of this gas, unmixed with air, is fatal to life; but, when mixed with twice its own bulk of air, it may be breathed for sometime without serious effects. When one part of fire-damp is mixed with thirty parts of air, by volume, it can be detected in the appearance of the flame of a lamp, which is drawn up to a point and elongated. If the mixture is increased up to two parts in thirty, the flame is surmounted by a blue halo, which partakes more or less of a brown color, according to the quantity of carbonic acid gas or "black damp," which may be present along with the fire-damp. When the fire-damp forms one in thirteen of air, the mixture becomes explosive, and when ignited, is converted into a mass of flame, with little explosive force; when the mixture is one in eight or ten of air, the explosive force is greatest. If the proportion be greater than one to eight or ten of air, the explosive force becomes gradually less, as we increase the proportion of fire-damp, until it reaches one in six of air, when it will no longer explode, but extinguishes lights.

The presence of "black damp," or of free nitrogen, in mixtures of fire-damp and air, lessens their explosive force; one-seventh, by volume, of black damp added to an explosive mixture, will render it non-explosive.

AFTER DAMP,

The result of an explosion of a mixture of fire-damp and air, is composed of—

		BY MEASURE. No. of Atoms.	Rel. Vol. per atom		Un-Combined Vol.	BY ATOMS. Comb'd Vol.	Vol. per cent.
Free Nitrogen			7.4	×	2	14.8	71.2
Carbonic Acid Gas	Carbon.	1.		×	2	2.	9.6
	Oxygen.	2.		×	1	2.	
Steam	Hydrogen,	2.		×	2	4.	19.2
	Oxygen,	2.		×	1	2.	
						24.8	100.0

Before the explosion there may be an excess of air or fire-damp beyond what is necessary to cause an explosion, which will remain unchanged and mixed with the after-damp. But there cannot be such an excess of air present as to render the after-damp fit for respiration, or the explosion could not take place. The limits are such that this is impossible. It assumes the appearance of a dense, misty vapor. It benumbs the faculties and produces a deadly lethargy. Where carbonic acid prevails in the mixture, a lamp will not burn. In cases where a larger proportion of nitrogen is present, the lamp will burn as in sulphuretted hydrogen, even after the miner is struck down, in this case life being extinguished before the flame.

As is seen in the table, "after-damp" contains about 71 parts free nitrogen, 9½ carbonic acid gas, and 19 parts of steam. The steam condensing after the explosion leaves, in round numbers, about 7½ parts of nitrogen and one part of carbonic acid gas out of 8½ parts. If there is more fire-damp present than is chemically changed, the explosive force is weaker, but the resultant after-damp is more deadly than when an excess of air is present in the mixture.

Carbonic Oxide, the White-Damp of Mines.

Assuming, as before, that the atomic volume of carbon is twice that of oxygen, its composition is as follows :

	By Atoms.	By Weight.	By Volume.
Oxygen.....	1	56.69	0½
Carbon	1	43.31	1
	1	100.00	1 cond'ed.

Its specific gravity is 975.195, that of air being 1000 at a temperature of 32° and under pressure of 14.7 pounds per square inch. One thousand cubic feet of carbonic oxide weighs 79.426 pounds. Air, under same conditions, will weigh 80.728 pounds. Carbonic oxide has a much more deleterious effect on the animal economy than carbonic acid. Air containing one per cent. of carbonic oxide kills warm-blooded animals, as shown by experiments of M. Felix Leblanc. Carbonic oxide is itself an inflammable gas, but does not support combustion of other bodies. It has no taste, but has a peculiar smell, and when mixed in the proportion of two of gas to five of air, it becomes explosive. It is easily kindled and burns with a blue flame, being transformed into carbonic acid by the process. This gas is, perhaps, never found in coal mines, except as the result of the burning of coal or wood, or the explosion of gunpowder. Such a proportion of this gas might be mixed with air that lights would burn, while life would become extinct.

Sulphuretted Hydrogen.

This gas is sometimes met with in coal mines. It is colorless, but distinguishable by its peculiar smell, which resembles that of addled eggs. It produces fainting fits and asphyxia, when present in small proportions with air. When pure, it acts as a powerful narcotic poison. It does not support combustion, but is itself inflammable, and burns when mixed with air ; when mixed with pure oxygen, it becomes explosive. It is composed as follows :

	By Atoms.	By Weight.	By Volume.
Sulphur.....	1	94.15	$\frac{1}{6}$
Hydrogen.....	1	5.85	1
	1	100.00	1

According to Bunsen, the specific gravity of this gas is 1178.88, that of air being assumed at 1000 under same conditions. According to some authorities, a horse died in an atmosphere which contained $\frac{1}{250}$ of its bulk of sulphuretted hydrogen. It arises from the decomposition of iron pyrites in mineral springs and the excrementitious matters which accumulate on working roads which have been used for years. Water will take up three times its own bulk of it, and its presence can be detected by its blackening white lead or paper dipped in sugar of lead and dried. It explodes at a lower temperature than fire-damp, and the common Davy lamp is, therefore, not a sufficient protection. When this gas is present in the air of mines, lights will burn in the mixture, so that if its smell does not make its presence known, it may prove fatal to life before its presence is detected.

Air in Mines.

What is necessary for rendering mines healthy and free from explosion is to keep a copious current of air circulating through the workings. No specific rule can be given as to how much air is necessary for the ventilation of different colleries. It should be *adequate* to "dilute and render harmless noxious gases." What the amount of this ventilation ought to be, circumstances only can determine. Each workman requires 209 gallons of fresh air hourly. Accounts of the air passing in a large number of collieries show that the amount varies from 8,000 to 180,000 cubic feet per minute.

The condition of the air in a colliery depends very much on the state of the air at the surface. As the weight of the atmosphere is shown by the height of the barometer, we can readily see that when the barometer has sunk, the air has become lighter ; and the pressure, which before assisted to keep in the gas, now being diminished, allows it to escape. For every degree which the barometer falls, the pressure per square foot is lessened more than 70 lbs. The following table will show the matter more clearly :

TABLE OF THE PRESSURE OF AIR AT DIFFERENT HEIGHTS OF THE BAROMETER.

RULE. Height of barometer in inches × ·4908 (the weight of a cubic inch of mercury) = pressure per square inch in pounds.

Height of barometer, in inches.	Pressure per sq. in. in pounds.	Pressure per sq. ft. in pounds.
27.0	13.25	1908.23
27.25	13.37	1925.89
27.5	13.49	1943.56
27.75	13.61	1961.23
28.0	13.74	1978.90
28.25	13.86	1996.56
28.5	13.98	2014.24
28.75	14.11	2031.91
29.0	14.23	2049.58
29.25	14.35	2067.24
29.5	14.47	2084.91
29.75	14.60	2102.58
30.0	14.72	2120.25
30.25	14.84	2137.92
30.5	14 96	2155.59
30.75	15.09	2173.26
31.0	15.21	2190.93

TABLE OF THE ELASTICITY OF ATMOSPHERES.

Elastic force in atmospheres.	Elastic force in lbs. per sq. inch.	Degrees of heat. F.	Difference of temperature in deg. F.	Volume in cubic feet, water being 1.	Velocity into a vacuum in ft. per sec.
1	14.7	212.00	——	1711	1566
2	29.4	250.52	38.52	905	1610
3	44.1	275.18	24.66	623	1638
4	58.8	293.72	18.54	479	1658
5	73.5	308.84	15.12	394	1674
6	88.2	320 36	11.52	331	1688
7	102.9	331.70	11.34	288	1700
8	117.6	341.93	10.26	255	1710
9	132.3	350.78	8.82	229	1720
10	147.0	358.88	8.10	209	1729
12	176.4	374.00	15.12	190	1742
15	180.5	392.86	18.86	135	1765
20	294.0	418.45	25.59	111	1786
30	441.0	457.16	38.71	77	1823
50	735.0	510.60	53.44	42	1873

PLANS OF WORKING TO SECURE PROPER VENTILATION.

Hints for the Mammoth Vein.—Anthracite Region.

The plans best suited to work different collieries vary with the character and location of the vein.

When the Vein is Soft and Shelly or Slippery, at an Angle of more than 50°, and Generating Large Quantities of Fire-Damp.

The great danger to be guarded against is the sudden liberation of gas should a breast "run," that is, should the coal at the face loosen and run out of its own gravity, only stopping when it chokes or fills up the open space below. To meet these conditions, the air-course may be driven above the gangway and used as a return, the fan being attached as an exhaust. The inside manway of each breast is connected with the gangway for the in-take, and a door is made below the cross-hole in each outside manway into the air-course for the return. This system furnishes each breast with a separate split of air.

One of its advantages is that the return air loaded with gas is kept from contact with lights, as the air-course is sealed up as soon as a breast is finished. In collieries where this system of working is followed the coal is soft. A new breast is worked up a few yards, but as soon as it is opened out the coal runs freely and the manways are pushed up on each side as rapidly as possible, to keep up with the face. The two miners, one on either side, sometimes finish a breast without being able to cross to each other. The work is done exclusively with Davy lamps, and when a breast "runs" the gas is liberated in such quantities that it frequently fills breasts from the top to the air-way before the men can get down the manway on the return side. When the gas reaches the cross-hole, it passes into the return air-way without reaching any part where men are working. Should a "run" of coal block a breast by closing the manway, it affects but that breast alone and does not affect the current of any other breast. As the gangway is the in-take, leakage at the batteries passes in to the breasts, as the cross-holes are

above their level and the gas is thus kept above the starter when at the draw-hole. The gangway, chutes and air-way are supplied by wooden pipes, which connect with a door behind the inside chute. If a breast runs up to the surface, it does not affect the return air-way, as it is in the solid.

Among the disadvantages urged against this system of working are the following:

It increases the friction, as the air must pass in the air-way all the distance from the breast to the fan, the area of the air-way being small in comparison to the gangway or in-take.

As the faces of the breasts are so much higher than the return air-way, the lighter gas must be forced down into the return against the buoyant power of its smaller specific gravity.

The reduction of friction obtained by splitting is neutralized by each split running up one small manway and down another; the advantage of running through two or more pillar headings and thus securing a shorter course being lost. This can be partially obviated by ventilating the breasts in pairs or groups, but the dangers avoided in splitting are increased.

The outside breasts are nearest the fan and receive the largest proportion of air. If an effort is made to preserve an equilibrium with regulators, friction is increased on the whole current, and less air secured with the same power.

Black-damp, which accumulates in the empty or partly empty breasts, works its way down and mixes with the in-take current, as there is no return current in the breast strong enough to carry it away, the return being closed in the monkey gangway.

All things considered, when the vein is soft and has a pitch of forty and upward, and emits large quantities of gas in sudden outbursts, as in running breasts, this system is the best that can be adopted.

When the Coal is Hard and Gas is not Freely Evolved.

The reverse of the system just described is followed at some collieries where the coal is hard and but little gas is encountered. The air-way is driven over the gangway or against the top, the fan being used to force the air inward

to the end of the air-way. The air is distributed as it returns, being held up at intervals by distributing doors placed along the gangway.

Among the advantages claimed for this plan are the following :

As the pressure is outward, it forces smoke and gas out at any openings which may exist from crop-hole falls or other causes.

The warm air from the interior of the mine returning up the hoisting slope or shaft prevents it from freezing.

As the current is carried from the fan to the end of each lift without passing through working places, the opening of doors as cars are passing, &c., does not interfere with the current.

If a locomotive is used, the smoke and gases generated by it are carried away from the men toward the bottom. Locomotives are generally used only from the main turnout to the bottom.

An objection to this system is that the gangway, as the return, is apt to be smoky. Starters and loaders are forced to work in more or less smoke, and even the mules work to disadvantage, while if gas is given off, it is passed out over the lights of those working in the gangway.

However, in places where there is but little gas and airways of large area can be driven, this plan works very satisfactorily, and some of the best ventilated collieries are worked upon it.

An objection advanced by some against forcing-fans is, that they increase the pressure, thus damming the gas back in the strata. In case the speed of the fan is slacked off, the accumulated gas may respond to the lessened pressure and spring out in large volumes from its pent-up state. This argument, however, works both ways. An exhaust fan, running at a given speed, is taking off pressure, and if anything occurs to block the in-take the pressure is diminished, and the gas responds to the decrease upon exactly the same principle.

Hints for the Smaller Veins.—Anthracite Region.

When the Vein is Small and Lays from Horizontal to about 10°.

Two gangways may be driven, the lower or main gangway being the in-take. Branch gangways should then be

driven diagonally or at a slant, with a panel or group of working places on each slant gangway. Large headings should connect the panels. In this system the air is carried directly to the face of the gangway and up into the breasts, returning back through the working places. The in-take and return are separated by a solid pillar, the only openings being the slant gangways on which are the panels.

The advantages of this plan are several :

The main gangway is solid, with the exception of the small cross-holes connecting with the gangway above ; these furnish air to the gangway and are small and easily kept tight. These stoppings should be built of brick, and made strong enough to withstand concussion.

A full trip of wagons can be loaded and coupled in each panel or section without interfering with or detaining the traffic on the main road ; one trip can be loaded while another is run out to the main gangway for transportation to the bottom.

The only break in the in-take current is when a trip of cars is taken out from or returns to a panel or section ; this can be partially provided against by double doors, set far enough apart to permit one to close after the trip before the other is opened. This distance can be secured by opening the first three breasts on a back-switch above the road through the gangway pillar, or by running each branch over the other far enough to obtain the distance for the double doors.

If it is not desired to carry the whole volume of air to the end of the air-way, a split can be made at each branch road. These will act as unequal splits in reducing friction, and although not theoretically correct, are preferable to dragging the whole current the full length of the workings.

The objections urged to this plan are :

That it involves too much expense in the large amount of narrow work at high prices necessary to open out a colliery ; that it necessitates a double track the whole length of the lift, and that the grade ascends into each panel or section. But the latter criticism falls, because the loss of power hauling the empty wagons up a slight grade is more than made up by the loaded wagons running down, while the mules are away putting a trip into another panel or section.

For a large colliery this is, without doubt, the best and cheapest system.

When the Vein is Small and lies at an Angle of more than 10°.

In small veins lying at an angle of more than 10°, and too small to permit an air-way over the chutes, it is more difficult to maintain ventilation. If air-holes are put through every few breasts, and a fresh start obtained by closing the back holes, or if an opening can be gotten through to the last lift as often as the current becomes weak, an adequate amount of air can be maintained, because the lift worked can be used as the in-take and the abandoned lift above as the return. To ventilate fresh ground, the filling of the chutes with coal will have to be depended upon, or a brattice must be carried along the gangway. This can be done for a limited distance only, as brattice leaks too much air. As a rule, collieries worked upon this plan are run along until the smoke accumulates and the ventilation becomes poor; then a new hole is run through and the brattice removed and used as before for the next section. This operation is repeated until the lift is worked out. Sometimes, to make the chutes tight, canvas covers are put on the drawholes, but, as they are usually left to the loaders to adjust, they are often very imperfectly applied. Then, as the coal is frequently very large, the air will leak through the batteries.

This plan works very satisfactorily if the openings are made at short intervals, say as frequent as every fifth breast, but the distance is usually much greater to save expense. As the power of the current decreases as the distance between the air-holes is increased, good ventilation is entirely a question of how often a cut-off is obtained.

An effective ventilation could be maintained in a small vein at a heavy angle by working with short lifts, say two lifts of fifty yards instead of one of a hundred as at present. The gangways should be frequently connected, and one used as an in-take and the other as a return. This would necessitate driving two gangways where one is now made to do, but the additional expense would be made up in the greater proportion of coal won.

HINTS ON THE TREATMENT OF PERSONS WHO HAVE BEEN SUFFOCATED WITH GAS.

The most melancholy accidents are continually happening from the want of a little precaution in dealing with gas. Lives have frequently been lost because of the neglect to lower a candle into old shafts or openings before descending them. How often when one man has been overcome by black-damp have others rushed to the rescue to fall and die beside him. Their lives would have been saved had a few buckets of water been dashed down where the first man fell, and very likely his life saved also.

When any one is thus immersed in carbonic acid, suffocation takes place in a very short time. Recovery from it is slow and extremely difficult, and only practical in the case of a very short continuance in the gas. It is often followed by some days' illness, and particularly by a violent headache.

The symptoms of suffocation are the sudden cessation of respiration, of the pulsations of the heart, and of the action of all the sensory functions; the countenance is swollen, and marked with reddish spots; the eyes become protruded; the features are discomposed, and the face is often livid.

The remedies, according to French authorities, are as follows:

1. The suffocated person is to be promptly withdrawn from the deleterious place, and exposed to good and pure air.

2. He is to be undressed, and effusions of cold water are to be thrown on the body, particularly over the head and neck.

3. He is to be required, if possible, to swallow cold water, slightly acidulated with vinegar.

4. Clysters should be given, two-thirds of cold water and one-third of vinegar; afterward to be followed up by the administration of others, with a strong solution of common salt, or of senna and Epsom salts.

5. Attempts should be made to irritate the pitutitary membrane with the feather end of a quill, which should be gently moved in the nostrils of the insensible person, or stimulate it by means of a bottle of volatile alkali, put under the nose.

6. Air should be introduced into the lungs by blowing with the nozzle of a bellows into one of the nostrils, and compressing the other with the fingers.

7. If these means do not sufficiently produce the effects which are expected, the body of the suffocated person preserving its heat (which generally occurs for a long time), it will be necessary to have recourse to blood-letting, of which the necessity will be clearly indicated if the face be red, the lips swollen, and the eyes protruding.

8. Blood-letting from the jugular vein will produce the speediest effect. In default of drawing it from that place, it should be taken from the foot.

9. For the last resource, an opening should be made in the trachea, and a small pipe introduced, through which the air should be passed by the aid of a little bellows.

Mr. Greenwell observes that it is necessary to apply these various remedies with the greatest promptness. The later they are in being employed, the more there is to fear that they will not be efficacious; and, as death does not certainly appear for a long time, they ought not to be discontinued, but when it is clearly confirmed. The absence of beating of the pulse is not a certain sign of death. The want of respiration is not sufficient to constitute it. Neither ought to be regarded as dead persons, those whose breath does not bedim the brightness of a glass; nor those of whom the members are stiff, and who appear insensible.

SAFETY LAMPS.

Sir Humphrey Davy thus describes his invention: The principle of my lamp is, that the flame, by being supplied with only a limited quantity of air, should produce such a quantity of azotic or carbonic acid gas, as to prevent the explosion of the fire-damp; and which, from the nature of its operations, should be rendered unable to communicate any explosion to the outer air. The wire gauze should not be more than 1-20th of an inch square; wire from 1-40th to 1-60th of an inch is the most convenient size, and there should be 28 wires, or 784 apertures per square inch.

Stephenson describes his lamp as made to contain burnt air above the flame, and to permit the fire-damp to come in below in small quantity, to be burnt as it comes in, the burnt air preventing the passing of explosion upwards, and the velocity of the current preventing its passing downwards.

The following figures represent the illuminating power of various lamps, the standard being a wax candle, six to the pound:

	Average number of lamps required to equal wax candle standard.
Davy's lamp, with gauze	8.00
Stephenson's lamp	18.50
Upton and Roberts's	24.50
Clanny's (glass)	4.25
Mueseler's (glass)	3.50
Parish's lamp, with gauze	2.75
Davy's lamp, without gauze	2.50
Common miner's candle, 30 to the pound.	2.00

A series of experiments on safety lamps was conducted by a Committee of the North of England Institute, who thus summarize their conclusions on an inflammable vapor observed to be given off by the gauzes when heated to a high temperature:

"(1.) That if a new gauze can be heated quickly to a red heat, it will, under certain circumstances, give off fumes which will inflame at that temperature. (2.) That similar results can be obtained by smearing a gauze

with oil. (3.) And further, that oil, on being poured over red-hot iron, will ignite.

"We may conclude, therefore, that this phenomenon is due to the presence of oil adhering to the gauze. That by heating to a high temperature, the oil is volatilised and removed, and the gauze can again be raised to a red heat without these results; but the action returns if any oil is smeared on the gauze; and cannot be removed, except by the gauze being again heated red-hot. That the ignition of the vapor externally takes place when the gauze is inserted within a red-hot tube; but not when a piece of red-hot iron is inserted within it.

"The gauze becomes much sooner heated red when put within the red-hot tube than when the iron is inserted within it.

"It is essential, therefore, that the gauze be rapidly heated red; if not, the oil is volatilised without being ignited.

"We come, therefore, to the following conclusions:

"(1.) That if rapidly heated to a high temperature, a safety-gauze gives off fumes which will ignite. (2.) That under all known conditions under which safety lamps are used this could not occur.

"That if a gauze be previously thoroughly acted on by caustic potash and sulphuric acid, it will not, on being heated by having a red-hot iron rod placed within it, give off fumes sufficiently inflammable to ignite on the *outside*. (There was considerable doubt about the gauze so heated firing even on the *inside*.)

"The conclusion to be arrived at, therefore, is that the oil is simply attached to the outside of, and is not incorporated in the body of the iron."

On the velocity at which it is necessary to move a lamp in an inflammable mixture to cause an explosion, and on various circumstances affecting the same, the committee say:

(1.) By revolving a Davy safety-lamp in certain mixtures, not only of ordinary coal gas and air, but also of the less explosive pit gas and air, at certain velocities, the external gas will be ignited. (2.) In a mixture of coal gas and air, the gas has been ignited by a lamp revolving at a great velocity, but the gauze of which has not attained a red heat, thus proving that in this experiment the flame passed through the gauze, and was not

ignited by the gauze itself attaining high temperature. (3.) In mixtures where there is a great excess of gas—in the proportion of one to five of air—the explosive force is very slight. the flame, which is of a yellow color, passes sluggishly over the box [in which the experiment was made], and the explosion is prolonged. Where the air is more abundant (in proportion of one of gas to eight of air, or thereabouts, the color of the flame is blue, and the explosion is violent and rapid. (4.) The lowest velocity at which the flame passes was 13 feet per second."

Further experiments were made in which a current of air and gas of known proportions and velocity were caused to impinge upon a lamp at rest, proving conclusively the exact velocity of current required to cause an explosion. The general results are thus stated :

"An inflammable mixture of pit gas and air, moving at the rate of 8 feet per second against a stationary Davy lamp without a shield, will explode. The addition of an ordinary shield to a Davy lamp is of little benefit; when the shield fits closely, and extends from the top to the bottom of the gauze, it affords some protection, but still at a velocity of 12 feet per second the flame passes.

"A Clanny lamp under similar circumstances will explode in a mixture passing at 9 feet per second.

"A Stephenson lamp will explode at 9 feet per second. In some experiments the flame passed the Stephenson lamp before the glass was in any way injured ; and in one experiment the glass was clearly observed to break *after* the lamp had fired the mixture, and was being withdrawn into the cold air for examination.

"A Mueseler lamp passed the flame as easily as a Davy lamp, viz., at 8 feet per second."

Messrs. W. Smethurst, F. G. S., and James Ashworth, mining engineers, made a series of exhaustive experiments at the Garswood Hall Colliery, near Wigan, England, in 1878, with all descriptions of safety lamps. They report the following practical results :

1. That the greater the diameter of the gauge, the quicker will the flame pass.

2. That in an explosive atmosphere, with the low velocity of seven feet per second, and without coal dust, the Davy lamp, as ordinarily constructed, is unsafe.

3. That whatever may be the height of the tin shield, it is no protection or safeguard against the flame passing; in fact, it adds to the danger.

4. That if a cylindrical glass shield is used, as in the Davy "Jack" lamp, and the smoke gauze made so long that the glass shield overlaps it by over a quarter of an inch, the safety of the lamp is immensely increased, and the flame will not pass until the glass is broken up by the heat, or the double thickness of gauze becomes heated sufficiently for the flame to pass.

5. That a Davy lamp, constructed after the design of Mr. Smethurst's Jack lamp, or Messrs. Ashworth and Woolrych's Jack-Davy lamp, is still safer.

6. That in many cases a Clanny lamp cannot be considered any safer than a Davy lamp, and this remark will also apply to the Bainbridge lamp.

7. That a ventilating current containing a very small percentage of gas, just enough to elongate the flame, and followed by a highly explosive body of gas, is the most severe test that a lamp can be put to, and very few can stand it.

THE BAROMETER AND WATER-GAUGE.

MERCURY is fourteen times heavier than water; therefore, if the pressure of the atmosphere will balance 34 ft. of water, it will only balance one-fourteenth part of that height of mercury, viz., a little more than 29 in. When the barometer is 27.00 in., the pressure per square foot is equal to 1908.23 lbs ; at 28.00 in. it is 1978.90 lbs. ; at 29.00 in. it is 2049.58 lbs. ; at 30.00 in. it is 2120.25 lbs., and at 31.00 in. it is 2190.93 lbs. To ascertain the amount of pressure per square foot, table No. 1 (p. 159) will be useful. Thus, at 30.00 in., the pressure, as above stated, is equal to 2120.25 lbs. on each square foot of surface. For the decimal .09 we have, by table No. 1, 6.36 lbs. ; 2120.25 + 6.36 = 2126.61 lbs., being the pressure on each square foot when the height of the barometer is 30.09 in. Suppose the mercury falls from this height to 29.47 in., then, by the table, this indicates a reduction of pressure equal to 43.81 lbs. per square foot. Required the amount in cubic feet of air and gas that may be expected to be given off for each 1000 cubic feet of open space in the goaves or other waste places.

At 30.09 the pressure is	2126.61	lbs.
29.47 "	2082.80	"
Difference	43.81	"

As 2126.61 : 43.81 : : 1000 : 20.60 cubic feet of gas, which (theoretically) may be expected to be given off by a reduction of pressure equal to that indicated above. A table of pressures is not, however, absolutely necessary for working the proportion.

Height of barometer	30.09
	29.47
Difference	.62

As 30.09 : .62 : : 1000 : 20.60 cubic feet.

If we divide the difference by 3, we shall obtain results sufficiently accurate for all practical purposes; thus $62 \div 3 = 20\frac{2}{3}$, or 20.66 cubic feet. Considerable experience in the use of the instrument in mines has shown that its indications are from one to two, or even three hours behind what is actually taking place; consequently, as an instrument for warning the furnace-men to "fire-up," or the engine tender to urge on the fan, it is worse than useless. It is, however, valuable to superintendents and other officials in the mines as an incentive to thought.

Respecting table No. 2 (p. 159), very little need be said. It shows the pressure in pounds and decimal parts of a pound for one inch, and decimal parts of an inch. The weight of a cubic foot of water = 1000 ozs.; therefore the pressure per square foot, one inch deep, will be 5.20 lbs. If the water-gauge stands at .25, or a quarter of an inch, the pressure per square foot is 1.30 lbs. For the pressure to be equal to a quarter of a pound to the square inch, or 36 lbs. per square foot, the difference of the water-level must be 6.92 in. The water-gauge is very useful as a check on the furnaceman, and also a tell-tale on the amount of friction in the air-courses, from whence may be inferred their state and condition.

TABLE OF CORRECTIONS TO BE ADDED TO THE READINGS FOR CAPILLARITY.

Diameter of tube.	CORRECTIONS FOR	
	Unboiled mercury.	*Boiled Mercury.
0.50	+ 0.01	+ 0.00
0.45	+ 0.01	+ 0.00
0.40	+ 0.02	+ 0.01
0.35	+ 0.02	+ 0.01
0.30	+ 0.03	+ 0.01
0.25	+ 0.04	+ 0.02
0.20	+ 0.06	+ 0.03
0.15	+ 0.09	+ 0.04
0.10	+ 0.14	+ 0.07

*The mercury is almost always boiled.

PRESSURE OF AIR, PER SQUARE FOOT, AS SHOWN BY THE BAROMETER AND WATER-GAUGE.

Table No. 1. Barometer.		Table No. 2. Water Gauge.	
In.	Lbs.	In.	Lbs.
1.00	70.68	1.00	5.20
.99	69.97	.99	5.14
.98	69.27	.98	5.09
.97	68.56	.97	5.04
.96	67.85	.96	4.99
.95	67.15	.95	4.94
.94	66.44	.94	4.88
.93	65.73	.93	4.83
.92	65.03	.92	4.78
.91	64.32	.91	4.73
.90	63.61	.90	4.68
.89	62.91	.89	4.62
.88	62.20	.88	4.57
.87	61.49	.87	4.52
.86	60.78	.86	4.47
.85	60.08	.85	4.42
.84	59.37	.84	4.36
.83	58.66	.83	4.31
.82	57.96	.82	4.26
.81	57.25	.81	4.21
.80	56.54	.80	4.16
.79	55.84	.79	4.10
.78	55.13	.78	4.05
.77	54.42	.77	4.00
.76	53.72	.76	3.95
.75	53.01	.75	3.90
.74	52.30	.74	3.84
.73	51.60	.73	3.79
.72	50.89	.72	3.74
.71	50.18	.71	3.69
.70	49.48	.70	3.64
.69	48.77	.69	3.58
.68	48.06	.68	3.53
.67	47.36	.67	3.48
.66	46.65	.66	3.43
.65	45.94	.65	3.38
.64	45.24	.64	3.32
.63	44.53	.63	3.27
.62	43.82	.62	3.22
.61	43.11	.61	3.17
.60	42.41	.60	3.12
.59	41.70	.59	3.06
.58	40.99	.58	3.01
.57	40.29	.57	2.96
.56	39.58	.56	2.91
.55	38.87	.55	2.86
.54	38.17	.54	2.80
.53	37.46	.53	2.75
.52	36.75	.52	2.70
.51	36.05	.51	2.65

Table No. 1. Barometer.		Table No. 2. Water Gauge.	
In.	Lbs.	In.	Lbs.
.50	35.34	.50	2.60
.49	34.63	.49	2.54
.48	33.93	.48	2.49
.47	33.22	.47	2.44
.46	32.51	.46	2.39
.45	31.81	.45	2.34
.44	31.10	.44	2.28
.43	30.39	.43	2.23
.42	29.69	.42	2.18
.41	28.98	.41	2.13
.40	28.27	.40	2.08
.39	27.57	.39	2.02
.38	26.86	.38	1.97
.37	26.15	.37	1.92
.36	25.44	.36	1.87
.35	24.74	.35	1.82
.34	24.03	.34	1.76
.33	23.32	.33	1.71
.32	22.62	.32	1.66
.31	21.91	.31	1.61
.30	21.20	.30	1.56
.29	20.50	.29	1.50
.28	19.79	.28	1.45
.27	19.08	.27	1.40
.26	18.38	.26	1.35
.25	17.67	.25	1.30
.24	16.96	.24	1.24
.23	16.26	.23	1.19
.22	15.55	.22	1.14
.21	14.84	.21	1.09
.20	14.14	.20	1.04
.19	13.43	.19	.98
.18	12.72	.18	.93
.17	12.02	.17	.88
.16	11.31	.16	.83
.15	10.60	.15	.78
.14	9.90	.14	.72
.13	9.19	.13	.67
.12	8.48	.12	.62
.11	7.77	.11	.57
.10	7.07	.10	.52
.09	6.36	.09	.46
.08	5.65	.08	.41
.07	4.95	.07	.36
.06	4.24	.06	.31
.05	3.53	.05	.26
.04	2.83	.04	.20
.03	2.12	.03	.15
.02	1.41	.02	.10
.01	.71	.01	.05

HEAT.

QUANTITIES of heat are expressed in units of weight of water heated one degree; as in pounds of water heated one degree Fahr.

Quantities of heat are sometimes also expressed in *units of evaporation:* that is, units of weight of water evaporated under the pressure of one atmosphere.

Heat which evaporates 1 lb. of water under one atmosphere = 966.1 units of heat.

STANDARD POINTS.

	Fahr.	Cent.	Reau.
Boiling point of water under one atmosphere	212°	100°	80°
Melting point of ice	32	0	0
Absolute zero; known by theory only, about	−461.2	−274	−219.2

9° Fahrenheit = 5° Centigrade = 4° Reaumur.

Temp. Fahr. = $\frac{9}{5}$ Temp. Cent. + 32°.

" " = $\frac{9}{4}$ Temp. Reau. + 32°.

Temp. Cent. $\frac{5}{9}$ (Temp. Fahr. −32°) = $\frac{5}{4}$ Temp. Reau.

Temp. Reau. $\frac{4}{9}$ (Temp. Fahr. −32°) $\frac{4}{5}$ Temp. Cent.

COMMUNICATION OF HEAT.

Conduction.—Taking the conducting power of gold at 100, the conducting powers of the undernoted bodies are as follows:

Gold	100.00	Tin	30.38
Platinum	98.10	Lead	17.96
Silver	97.30	Marble	2.34
Copper	89.82	Porcelain	1.22
Iron	37.41	Brick Earth	1.13
Zinc	36.37		

Transmission.—If the quantity of radiant heat transmitted through air be expressed by 100, the following numbers will express the quantity transmitted through an equal thickness of the substances named below:

Air	100	Rape Oil	30
Rock Salt (transparent)	92	Tourmaline	27
Flint Glass	67	Sulphuric Ether	21
Bisulphuret of Carbon,	63	Gypsum	20
Calcareous Spar (transparent)	62	Sulphuric Acid	17
Rock Crystal	62	Nitric Acid	15
Topaz, brown	57	Alcohol	15
Crown Glass	49	Alum Crystals	12
Oil of Turpentine	31	Water	11

RADIATION, ABSORPTION, AND REFLECTION OF HEAT.

Taking the radiating and absorbing power of a smoke-blackened surface at 100 the reflecting power of such a surface will be 0; and the radiating and absorbing powers, and also the reflecting powers of the various substances enumerated beneath will be as they stand in the following table, compiled from the experiments of MM. de la Provostaye and Desains.

Name of Substance.	Radiating and absorbing power.	Reflecting power.
Smoke-blackened surface	100	0
Carbonate of Lead	100	0
Writing Paper	98	2
Glass	90	10
China Ink	85	15
Gum Lac	72	28
Silver Foil on Glass	27	73
Cast Iron, polished	25	75
Mercury	23	77
Wrought Iron, polished	23	77
Zinc, polished	19	81
Platinum, polished	17	83
Tin	14	86
Metalic Mirrors, a little tarnished,	17	83
Brass, cast imperfectly, polished,	11	89
Copper, hammered or cast	7	93
Gold Plating	5	95
Silver, cast and well polished	3	97

TABLE OF SPECIFIC HEATS.

Water	1.0000	Oil	0.5200	Sulphur	0.1850
Hydrogen Gas	3.2936	Nitrog'n Gas	0.2754	Iron	0.1138
Aqueous Vapor	0.8470	Air	0.2669	Zinc	0.0955
Alcohol	0.7000	Oxygen	0.2361	Mercury	0.0332
Ether	0.6600	Carbonic Acid	0.2210	Platinum	0.0324
		Charcoal	0.2631	Gold	2.2998

SPECIFIC HEAT OF IRON.

From 32	to 212	degrees	0.1098
" 392	"		0.1150
" 572	"		0.1218
" 662	"		0.1255

PROGRESSIVE SPECIFIC HEAT.

	Bet. 32 and 212 deg.	Bet. 32 and 572 deg.
Of Mercury	0.0330	0.2350
Zinc	0.0927	0.1015
Antimony	0.0507	0.0547
Silver	0.0557	0.0611
Copper	0.0949	0.1013
Platinum	0.0335	0.0355
Glass	0.1770	0.1900

TABLE OF LATENT HEATS.

LIQUIDS.

Of Water	140 deg.	Fahr.	Of Beeswax	175 deg.	Fahr.
Sulphur	143.7	"	Zinc	494	"
Sp'rmac'ti	145	"	Tin	500	"
Lead	162	"	Bismuth	550	"

VAPORS.

Of Water 212° Fahr.	1000	Of Nitric Acid	550
Alcohol	457	Ammonia	865.9
Ether	312.9	Vinegar	903
Oil of Turpentine	183.8		

LINEAL EXPANSION OF METALS.

Produced by raising their temperatures from 32° to 212° Fahr.

Zinc	1 part in	322	Gold	1 part in	682
Platinum	"	351	Bismuth	"	719
Tin (pure	"	403	Iron	"	812
Tin (impure)	"	500	Antimony	"	923
Silver	"	524	Palladium	"	1000
Copper	"	581	Platinum	"	1100
Brass	"	584	Flint Glass	"	1248

TABLE OF THE EFFECTS OF HEAT ON DIFFERENT METALS.

	Fahrenheit. Degrees.
Extremity of the scale of Wedgewood	uncertain.
Platinum melts	uncertain.
Wrought Iron fuses	2910
Cast Iron melts	2787
Welding Heat of Bar Iron	2420
Fine Gold melts	2100
Fine Silver melts	1850
Copper melts	1990
Brass melts	1870
Iron red-hot in daylight	1207
Lead melts	612
Mercury boils	600
Bismuth melts	476
Tin 1, and Lead 4, melt	460
Tin melts	442
Tin 3, and Lead 2, or Tin 2, and Bismuth 1, melt,	334
Tin and Bismuth, equal parts, melt	283
Bismuth 5, Tin 3, and Lead 2, melt	212

TABLE OF THE EXPANSION OF SOLIDS.

By increasing the temperature from 32° to 212°, the length of the bar at 32° being 1.00000000.

Glass Tube	1.00082800	Gold	1.00150000
Platinum	1.00088420	Lead	1.00286700
Antimony	1.00108300	Brass	1.00186671
Cast Iron	1.00111111	Wrought Iron	1.00125800
Steel	1.00118999	Zinc	1.00294200
Blistered Steel	1.00112500	Spelter Solder, Brass 2, Zinc.	1.0020580
Steel, hardened	1.00122502		
Bismuth	1.00139200	Soft Solder, Lead 2, Tin 1	1.00250800
Silver	1.00189000		
Tin	1.00217298	Copper 8, Tin 1	1.00181700
		Palladium	1.00100000

THE EXPANSION OF LIQUIDS IN VOLUME FROM 32° TO 212° FAHR.

1000 parts of	Water	become	1046
"	"	Oil	"	1080
"	"	Mercury	"	1018
"	"	Spirits of Wine	"	1110
"	"	Air	"	1373

VOLUME OF A GASEOUS BODY AT DIFFERENT TEMPERATURES.

The table given, on page 165, taken from Lardner's *Handbook of Natural Philosophy*, shows the changes of volume of a gaseous body consequent on given changes of temperature. In column V are expressed in cubic inches the volumes which a thousand cubic inches of air, at 32 degrees Fahrenheit, will have at the temperature in degrees Fahrenheit expressed in column T, the air being supposed to be maintained constantly at the same pressure.

COMBUSTION.

The following table shows the degrees of rarefaction of common air, at which the combustion of some inflammable bodies ceases, both with and without the appendage of a coil of platinum wire.

	Without Platinum.	With Platinum.
Olefiant gas ceases to burn in air rarefied	.....	11 to 12 times.
Carbureted Hydrogen	.....	4 "
Carbonic Oxide	.....	6 "
Alcohol, Wax Taper	5 to 6 times	7 to 8 "
Sulphureted Hydrogen	7 "	
Sulphur	15 to 20 "	
Phosphorus	60 "	

The temperature necessary to produce combustion is different for different substances. Phosphorus combines with oxygen and burns in the atmosphere if raised to 148 degrees. Hydrogen will not burn till raised to incandescence. According to Sir H. Davy, the temperatures necessary to the combustion of the several combustibles here named, are in the following order:

1 Phosphorus.
2 Phosphoreted Hydrogen.
3 Hydrogen and Chlorine.
4 Sulphur.
5 Hydrogen and Oxygen.
7 Olefiant Gas.
7 Sulphureted Hydrogen.
8 Alcohol.
9 Wax.
10 Carbonic Oxide.
11 Carbureted Hydrogen.

T.	V.	T.	V.	T.	V.	T.	V.	T.	V.
—49	834.7	8	951.0	65	1067.3	122	1183.7	179	1300.0
—48	836.7	9	953.1	66	1069.4	123	1185.7	180	1302.0
—47	838.8	10	955.1	67	1071.4	124	1187.8	181	1304.1
—46	840.8	11	957.1	68	1073.5	125	1189.8	182	1306.1
—45	842.8	12	959.2	69	1075.5	126	1191.8	183	1308.2
—44	844.9	13	961.2	70	1077.6	127	1193.9	184	1310.2
—43	846.9	14	963.3	71	1079.6	128	1195.9	185	1312.2
—42	849.0	15	965.3	72	1081.6	129	1198.0	186	1314.3
—41	851.0	16	967.3	73	1083.7	130	1200.0	187	1316.3
—40	853.1	17	969.4	74	1085.7	131	1202.0	188	1318.4
—39	855.1	18	971.4	75	1087.8	132	1204.1	189	1320.4
—38	857.1	19	973.5	76	1089.8	133	1206.1	190	1322.4
—37	859.2	20	975.5	77	1091.8	134	1208.2	191	1324.5
—36	861.2	21	977.6	78	1093.9	135	1210.2	192	1326.5
—35	863.3	22	979.6	79	1095.9	136	1212.2	193	1328.6
—34	865.3	23	981.6	80	1098.0	137	1214.3	194	1330.6
—33	867.3	24	983.7	81	1100.0	138	1216.3	195	1332.6
—32	869.4	25	985.7	82	1102.0	139	1218.4	196	1334.7
—31	871.4	26	987.8	83	1104.1	140	1220.4	197	1336.7
—30	873.5	27	989.8	84	1106.1	141	1222.4	198	1338.8
—29	875.5	28	991.8	85	1108.2	142	1224.5	199	1340.8
—28	877.6	29	993.9	86	1110.2	143	1226.5	200	1342 9
—27	879.6	30	995.9	87	1112.2	144	1228.6	201	1344.9
—26	881.6	31	998.0	88	1114.3	145	1230.6	202	1346.0
—25	883.7	32	1000.0	89	1116.3	146	1232.7	203	1349.0
—24	885.7	33	1002.0	90	1118.4	147	1234.7	204	1351.0
—23	887.8	34	1004.1	91	1120.4	148	1236.7	205	1353.1
—22	889.8	35	1006.1	92	1122.4	149	1238.8	206	1355.1
—21	891.8	36	1008.2	93	1124.5	150	1240.8	207	1357.1
—20	893.9	37	1010.2	94	1126.5	151	1242.9	208	1359.2
—19	895.9	38	1012.2	95	1128.6	152	1244.9	209	1351.2
—18	898.0	39	1014.3	96	1130.6	153	1246.9	210	1363.3
—17	900.0	40	1016.3	97	1132.7	154	1249.0	211	1365.3
—16	902.0	41	1018.4	98	1134.7	155	1251.0	212	1367.3
—15	904.1	42	1020.4	99	1136.7	156	1253.0	213	1369 4
—14	906.1	43	1022.4	100	1138.8	157	1255.1	214	1371.4
—13	908.2	44	1024.5	101	1140.8	158	1257.1	215	1373.5
—12	910.2	45	1026.5	102	1142.9	159	1259.2	216	1375.5
—11	912.2	46	1028.6	103	1144.9	160	1261.2	217	1377.5
—10	914.3	47	1030.6	104	1147.0	161	1263.3	218	1379.6
— 9	916.3	48	1032.7	105	1149.0	162	1265.3	219	1381.6
— 8	918.4	49	1034.7	106	1151.0	163	1267.3	220	1383.7
— 7	920.4	50	1036.7	107	1153.1	164	1269.4	230	1404.1
— 6	922.5	51	1038.8	108	1155.1	165	1271.4	240	1424.5
— 5	924.5	52	1040.8	109	1157.1	166	1273.5	250	1444.9
— 4	926.5	53	1042.9	110	1159.2	167	1275.5	260	1465.3
— 3	928.6	54	1044.9	111	1161.2	168	1277.5	270	1485.7
— 2	930.6	55	1046.9	112	1163.3	169	1279.6	280	1506.1
— 1	932.7	56	1049.0	113	1165.3	170	1281.6	290	1526.5
0	934 7	57	1051.0	114	1167.3	171	1283.7	300	1546.9
1	936.7	58	1053.1	115	1169.4	172	1285.7	400	1751.0
2	938 8	59	1055.1	116	1171.4	173	1287.8	500	1955.1
3	940.8	60	1057.1	117	1173.5	174	1289.8	600	2159.2
4	942.9	61	1059.2	118	1175.5	175	1291.8	700	2363.3
5	944.9	62	1061.2	119	1177.6	176	1293.9	800	2567.3
6	947.0	63	1063.3	120	1179.6	177	1295.9	900	2773.5
7	949.0	64	1065.3	121	1181.6	178	1298.0	1000	2947.1

TABLE SHOWING ORDINARY MELTING POINTS OF VARIOUS SUBSTANCES.

Name of Substance.	Degs. Fahr.	Authority.
Platinum	3082	Clarke.
English Wrought Iron	2912	Vauquelin.
Steel	2552	Pouillet.
Cast Iron	2192	"
" Manganese	2282	"
" Brown, fusible	2192	"
" White, "	2012	"
Gold, very pure	2282	"
Gold Coin	2156	"
Copper	1922	"
Brass	1859	Daniel.
Silver, very pure	1832	Pouillet.
Bronze	1652	"
Antimony	810	"
Zinc	705	G. Moroeau.
Lead	590	Irvine.
Bismuth	505	Pouillet.
Tin	446	"
Sulphur	237	Dumas.
Soda	194	Gay Lussac.
Potash	136	Pouillet.
Phosphorus	109	"
Stearic Acid	158	"
Wax, bleached	154	Person.
Margaric Acid	140	Pouillet.
Stearine	109	"
Spermaceti	120	"
Tallow	92	"
Ice	32	"
Oil of Turpentine	14	"
Mercury	— 38.2	"

COLORS EXPRESSIVE OF THE CORRESPONDING HIGH TEMPERATURES REDUCED TO FAHRENHEIT. (*Becquerel*).

Faint red	960	degrees Fahr.
Dull red	1290	" "
Brilliant red	1470	" "
Cherry red	1650	" "
Bright cherry red	1830	" "
Orange	2010	" "
Bright Orange	2190	" "
White heat	2370	" "
Bright white heat	2550	" "
Brilliant white	2730	" "
Melting point of cast iron	2786	" "
Greatest heat of iron blast furnace	3300	" "

SURVEYING, &c.

THE MINER'S COMPASS.

In making surveys with the compass it is very important to take into consideration the declination of the needle, or its variation from the true meridian.

Prior to about 1800 the variation was east, or the needle was moving eastward. Since that time or about the year 1805 it began to move westward, and has been doing so ever since. The movement seems to be increasing each year. About ten or twelve years ago it moved at the rate of about five minutes per year, while now it is moving about six minutes per year. The variation from the true meridian for the Southern Anthracite coal region is now about 5° 49′ (five degrees 49 minutes) west.

The variation of the needle is the same underground as on the surface.

The following method may be adopted for finding the true north, and this being done, it is easy at any time to find the variation of any compass.

As in these northern latitudes the sun is due south at twelve o'clock noon (that is, when the sun is at its highest point), to obtain its direction then will be to ascertain the meridian line, and this may be done by erecting a thin vertical rod on a level drawing-board, and observing shortly before mid-day, the end of the shadow caused by the rod. From this point, and with the rod as a centre, describe an arc of a circle, and notice when the end of the shadow again touches it; midway between these two points, make a mark, and a line drawn from the rod to this mark will represent the line of the meridian. This line might be extended out to some length, and pegs put in, so that the variation of the compass might be observed at any time.

POINTS OF THE COMPASS AND THEIR CORRESPONDING ANGLES WITH THE MERIDIAN.

North.		Points.		Points.	South.	
...		0¼...	2°48′45″	...0¼	...	
....		0½....	5 37 30	....0½	....	
....		0¾....	8 26 15	....0¾	....	
N. by E.	...N. by W.	1	11 15 0	...1	S. by E.	...S. by W.
...		1¼...	14 3 45	...1¼	...	
...		1½...	16 52 30	...1½	...	
...		1¾...	19 41 15	...1¾	...	
N N.E.	...N.N.W.	2 ...	22 30 0	...2	S.S.E.	...S.S.W.
...		2¼...	25 18 45	...2¼	...	
...		2½...	28 7 30	...2½	...	
...		2¾...	30 56 15	...2¾	...	
N.E. by E.	...N.W. by N.	3 ...	33 45 0	...3	S.E. by S.	...S.W. by S.
...		3¼...	36 33 45	...3¼	...	
...		3½...	39 22 30	...3½	...	
...		3¾...	42 11 15	...3¾	...	
N.E. ...	... N.W. ...	4 ...	45 0 0	...4	S.E. ...	...S.W.
...		4¼...	47 48 45	...4¼	...	
...		4½...	50 37 30	...4½	...	
...		4¾...	53 26 15	...4¾	...	
N.E. by E.	...N.W. by W.	5 ...	56 15 0	...5	S.E. by E	...S.W. by W.
...		5¼...	59 3 45	...5¼	...	
...		5½...	61 52 30	...5½	...	
...		5¾...	64 41 15	...5¾	...	
E.N.E.	...W.N.W.	6 ...	67 30 0	...6	E.S.E.	...W S.W.
...		6¼...	70 18 45	...6¼	...	
...		6½...	73 7 30	...6½	...	
...		6¾...	75 56 15	...6¾	...	
E. by N.	...W. by N.	7 ...	78 45 0	...7	E. by S.	...W. by S.
...		7¼...	81 33 45	...7¼	...	
...		7½...	84 22 30	...7½	...	
...		7¾...	87 11 15	...7¾	...	
East	...West ...	8 ...	90 0 0	...8	East	...West.

ON THE USE OF THE FOLLOWING TABLE OF INCLINE MEASURE.

In surveying workings when the veins dip at angles from the horizontal, the following table to reduce the incline measure to distance upon a level will be a great convenience:

Column 1.—The angle which inclined planes make with the horizon, and is found with the gradometer, theodolite, &c.

Column 2.—The vertical height gained on each yard or 36 inches of horizontal or base measurement, in inches.

Column 3.—Another way of expressing the amount of gradient obtained by dividing the horizontal or base measurement by the vertical or sine measurement.

Column 4.—The length of the base or horizontal measure of a right-angled triangle, the hypothenuse being one or unity. To obtain the horizontal measurement by proportion when the hypothennse or incline and angle is given:

As 1 : figures in column 4 :: length of plane : the base or horizontal measure.

Example:

A slope is 870 links in depth, and pitches at 35°. What is the horizontal distance, or how long should it be made upon the map?

Solution:

Opposite 35′ on the first or degree column find .81915; then as 1: .81915 :: 870 : 712.66 or $712\frac{3}{4}$ links nearly. The same result will be obtained by deducting the number of links per chain by figures in column 6.

Column 5.—Gives the length of the sine or perpendicular side of a right-angled triangle when the hypothenuse is 1 or unity.

To find the height gained on a slope or slant when the length and degrees are given.

Example 1:

In a breast of 400 links in length, pitching 36°, what is the vertical height gained?

Solution:

Opposite 36 on column 1 find .58778 as length of sine; then by proportion.

As 1 : .58778 :: 400 links : 235.112 links, then 235.112× 7.92=155 feet 2 inches.

Example 2:

If a wagon weighing 4 tons is being hoisted up a slope of 30°, what is the strain on the rope, independent of friction and weight of rope?

Opposite 30 on column 1 find on column No. 5 .5 or $\frac{1}{2}$, slope length being 1; then as the vertical height is to the length of the slope, so is the strain on the rope to the weight or by proportion—

As .5 : 1 .: 4 tons : 2 tons.

Column 7.—This column is made by finding the gravity due for 1 ton by the last problem, or by multiplying the number of pounds in a ton by the sine of the different angles.

Example:

The weight pulled up a slant is 70 cwt. or 7840 pounds, and the pitch is 26°; how much is the weight equal to, if hoisted vertically up a shaft, or what is the load on the rope?

Solution:

Opposite 26 on column 1 find on column 7 the figures 981.94; then as 2240 pounds or 1 ton : 981.94 pounds :: 7840 pounds : 3437 pounds or 30 cwt. 2 qrs. 21 pounds. Then from a table of strength of ropes, we find the required rope for work, due allowance being made for weight of rope, friction, factor of safety, &c.

Column 8.—Shows the ratio of increase in cubic contents of coal seams from 1° to 50°, and is obtained by the formula.

$\frac{1 \times 4840}{\text{co-sine.}}$ the number of square yards in an acre or figures in column 4.

Example:

How many cubic yards are in a field of 12 acres containing a seam of coal 6 feet thick, at a pitch of 30°? Find opposite 30 in column 1 in column 8 the yards per acre, 5588.78; then 6 feet are 2 yards, which is the thickness of vein; then $5588.78 \times 2 = 11177.56$ cubic yards, or the contents per acre, and 11177.56×12, the number of acres.=134,130.72, the contents of the tract.

TABLE OF INCLINED MEASURES.

1.	2.	3.	4	5.	6.	7.	8.
1	0 63	57.29	.99985	.01745	0.01	39.08	4840.72
2	1.26	28.63	.99939	.03490	0.06	78.18	4842.95
3	1.88	19.09	.99863	.05231	0.14	117.24	4846.63
4	2.51	14.29	.99756	.06976	0.24	156.26	4851.83
5	3.15	11.42	.99619	.08716	0 38	195.21	4858.51
6	3.78	9.51	.99452	.10453	0.55	234.14	4866.66
7	4.42	8.14	.99255	.12187	0.74	272.98	4876.32
8	5.06	7.11	.99027	.13917	0.97	311.74	4887.55
9	5.70	6.31	.98769	.15643	1.23	350.40	4900.32
10	6.34	5.67	.98481	.17365	1.52	388.97	4914.65
11	6.99	5.14	.98163	.19081	1.84	427.41	4930.57
12	7.65	4.70	.97815	.20791	2.19	465.71	4948.11
13	8.31	4 33	.97437	.22495	2.56	503.88	4967.31
14	8.97	4.01	.97030	.24192	2.97	541 90	4988.14
15	9.64	3.73	.96593	.25882	3.40	579.75	5010.71
16	10.32	3.48	.96126	.27564	3.87	617.43	5035.05
17	11.00	3.27	.95630	.29237	4.37	654.90	5061.17
18	11.69	3.07	.95106	.30902	4.89	692.20	5089.05
19	12.39	2.90	.94552	.32557	5.45	729.27	5118.87
20	13.10	2.74	.93969	.34202	6.03	766.12	5150.63
21	13.82	2.60	.93358	.35837	6.64	802.74	5184.34
22	14.54	2.47	.92718	.37461	7.28	839.12	5220.12
23	15.27	2.35	.92050	.39073	7.95	875.23	5258.01
24	16.02	2.24	.91355	.40674	8 65	911.09	5298.01
25	16.78	2.14	.90631	.42262	9 37	946.66	5340.33
26	17.56	2.05	.89879	.43837	10.12	981.94	5385.01
27	18.34	1.96	.89101	.45399	10.90	1016.93	5432.03
28	19.14	1.88	.88295	.46947	11.71	1051.61	5481.62
29	19.95	1.80	.87462	.48481	12.54	1085.97	5533.83
30	20.78	1.73	.86602	.5	13.40	1120.00	5588.78
31	21.62	1.66	.85717	.51504	14.28	1153.68	5646.48
32	22.49	1.60	.84805	.52992	15.19	1187 02	5707.21
33	23.37	1.54	.83867	.54464	16.13	1219.99	5771.04
34	24.28	1.48	.82904	.55919	17.10	1252.58	5838.07
35	25.20	1.42	.81915	.57358	18.08	1284.81	5908.56
36	26.15	1.37	.80902	.58778	19.10	1316.62	5982 54
37	27.12	1.32	.79864	.60181	20.14	1348.05	6060.30
38	28.12	1.28	.78801	.61566	21.20	1379.07	6142.05
39	29.14	1.23	.77715	.62932	22.28	1409.67	6228.01
40	30.21	1.19	.76604	.64279	23.40	1439.84	6318.20
41	31.29	1.15	.75471	.65606	24.53	1469.57	6413.05
42	32.41	1.11	.74314	.66913	25.69	1498.85	6512.90
43	33.56	1.07	.73135	.68200	26.86	1527.68	6617.89
44	34.76	1.03	.71934	.69466	28.07	1556.03	6728.38
45	36.00	1.00	.70711	.70711	29.29	1583.92	6844.76
46	37.27	.96	.69466	.71934	30.53	1611.32	6967.43
47	38.60	.93	.68200	.73135	31.80	1638.22	7096.77
48	39.98	.90	.66913	.74314	33.09	1664.63	7233.27
49	41.41	.87	.65606	.75471	34.39	1690.55	7377.37
50	42.90	.84	.64279	.76604	35.72	1715.92	7529.67
51	44.46	.81	.62932	.77715	37.07	1740.81	
52	46.07	.75	.61566	.78801	38.43	1765.14	
53	47.77	.73	.60181	.79864	39.82	1788.95	

TABLE OF INCLINED MEASURES.—Continued.

1.	2.	3.	4.	5.	6.	7.	8.
54	49.54	.70	.58778	.80902	41.22	1812.20	
55	51.41	.67	.57358	.81915	42.64	1834.89	
56	53.36	.65	.55919	.82904	44.08	1857.04	
57	55.44	.62	.54464	.83867	45.54	1878.62	
58	57.61	.62	.52992	.84805	47.01	1899.63	
59	59.92	.60	.51504	.85717	48.50	1920.06	
60	62.35	.58	.5	.86602	50.00	1939.88	
61	64.94	.55	.48481	.87462	51.52	1959.14	
62	67.69	.53	.46947	.88295	53.05	1977.80	
63	70.65	51	.45399	.89101	54.60	1995.86	
64	73.80	.49	.43837	.89879	56.16	2013.28	
65	77.20	.47	.42262	.90631	57.74	2030.13	
66	80.86	.45	.40674	.91355	59.33	2046.35	
67	84.81	.42	.39073	.92050	60.93	2061.92	
68	89.10	.40	.37461	.92718	62.54	2076 88	
69	93.77	.38	.35837	.93358	64.16	2091.21	
70	98.91	.36	.34202	.93969	65.80	2104.90	
71	104.53	.34	.32557	.94552	67.44	2117.96	
72	110.80	.32	.30902	.95106	69.10	2130.37	
73	117.73	.31	.29237	.95630	70.76	2140.11	
74	125.56	.29	.27564	.96126	72.41	2153.22	
75	134.37	.27	.25882	.96593	74.12	2163.68	
76	144.40	.25	.24192	.97030	75.81	2173.47	
77	155.90	.23	.22495	.97437	77.50	2182.58	
78	169.36	.21	.20791	.97815	79.21	2191.05	
79	185.20	.19	.19081	.98163	80.92	2198.85	
80	204.10	.18	.17365	.98481	82.63	2205.97	
81	227.34	.16	.15643	.98769	84.36	2212.42	
82	256 11	.14	.13917	.99027	86.08	2218.20	
83	293.13	.12	.12187	.99253	87.81	2223.26	
84	342.60	.10	.10453	.99452	89.55	2227.72	
85	411.27	.09	.08716	.99619	91.28	2231.46	
86	514.52	.07	.06976	.99756	93.02	2234.53	
87	——	—	.05234	.99863	94.77	2236.93	
88	——	—	.03490	.99939	96.51	2238.63	
89	——	—	.01745	.99985	98.25	2239.66	

It is obviously unnecessary to give this above (about) 50 degs.

HOW TO USE THE GRADOMETER, OR GRADING LEVEL.

This instrument is of great utility in finding the pitch or angle of slopes, roads, chutes, pipes, &c., and for making profiles of breasts or workings, to find the perpendicular height attained when approaching old levels or workings full of water or gas.

To find the angle of dip, place the blade in the groove of the leg containing the spirit level; place the other leg upon the surface or plane of which you wish to ascertain

the pitch or angle; open until the spirit-level shows the bubble in the centre of the glass; the angle up to 45° will be found on the blade.

To find the angle of dip when it is over 45°, open the blade until it makes a right angle with the leg; place on the surface or plane, and fold in the leg containing the spirit level until the bubble shows in the centre of the glass; push the blade into the groove, taking care not to move the legs, and the degrees indicated taken from 90° will be the angle of dip required.

TO ASCERTAIN THE SCALE OF A PLAN OR MAP, WHEN IT IS NOT STATED.

When the area of any portion is known, the scale may be found by measuring that portion by any scale. Then use the following formula :—

a = area as given on the plan.
s = assumed scale.
x = correct scale.
m = area by assumed scale, then

$$\sqrt{\frac{s^2 \times a}{m}} = x \text{ or, } x^2 = \frac{s^2 \times a}{m}$$

USEFUL NUMBERS IN SURVEYING.

For converting			Multipler.	Converse.
Feet	into	links.....	1.515	.66
Yards	"	links.....	4.545	.22
Sq. feet	"	acres.....	.0000229	43560
Sq. yards	"	acres.....	.0002066	4840
Feet	"	miles.....	.00019	5280
Yards	"	miles.....	.00057	1760
Chains	"	miles.....	.0125	80

COMPUTATION OF ACREAGE.

Divide the area into convenient triangles, and multiply the base of each triangle in links by half the perpendicular in links; cut off five figures to the *right*, the remaining figures will be acres; multiply the five figures so cut off by 4, and again cut off five figures, and the remainder is in roods, multiply the five figures by 40, and again cut off for perches.

STEAM-ENGINES, PUMPS, &c.

Steam is a compound of one part by weight of hydrogen, with eight parts by weight of oxygen, making nine parts by weight of steam. Its composition by volume is one volume of hyydrogen to half a volume of oxygen, making one volume of steam in the perfectly gaseous state. Hence when steam is in the perfectly gaseous state, its density at a given pressure and temperature is to that of hydrogen as 9 to 1; to that of oxygen as 9 to 16; and to that of air as 5 to 8.

Actual steam, especially if in contact with liquid water has almost always a greater density than that corresponding to the perfectly gaseous state.

The *latent heat* of steam is the heat which disappears in converting one pound of water from the liquid to the vaporous state. At the atmospheric boiling point (100° Cent. or 212° Fahr.) the latent heat of one pound of steam is nearly 537 thermal units Cent., or 966 thermal units Fahr., that is, nearly equal to the heat which would raise the temperature of 537 lbs. of water one Centigrade degree, or 966 lbs. of water one degree of Fahrenheit, and its value dimishes by 0.7 of a thermal unit nearly, for every increase of one degree in the boiling point.

The following table, the result of the experiments of M. Regnault, gives the sensible and latent heats of steam.

Temperature in degs. Fahr.	Latent heat.	Sum of sensible and latent heats.	Temperature in degs. Fahr.	Latent heat.	Sum of sensible and latent heats.
32° ...	1092.6 ...	1124.6	248° ...	936.6 ...	1187.6
50 ...	1080.0 ...	1130.0	266 ...	927.0 ...	1193.0
68 ...	1067.4 ...	1135.8	284 ...	914 4 ...	1198.4
86 ...	1054.8 ...	1140.8	302 ...	901.8 ...	1203.8
104 ...	1042.2 ...	1146 2	320 ...	899.2 ...	1209.2
122 ...	1029.6 ...	1151.6	338 ...	874.8 ...	1212.8
140 ...	1017 0 ...	1157.0	356 ...	862 2 ...	1218.2
158 ...	1004.4 ...	1162.4	374 ...	849.6 ...	1223.6
176 ...	991.8 ...	1167.8	392 ...	835.2 ...	1227.2
194 ...	979.2 ...	1173.2	410 ...	822.6 ...	1232.6
212 ...	966.6 ...	1178.6	428 ...	808.2 ...	1236.2
230 ...	952.2 ...	1182.2	446 ...	795.6 ...	1241.6

EXPANSION OF STEAM.

Increase of efficiency from expansive working. I = initial pressure of steam in lbs. per square inch; R = ratio of cut-off, as 2 for $\frac{1}{2}$, 8 for $\frac{1}{8}$: M = mean pressure throughout the stroke in lbs. per square inch; T = terminal pressure.

$$M = \frac{1}{R} \times \text{hyp. log } (R + 1) \quad \frac{I}{R} = T.$$

Proportion of stroke at which steam is cut off.	R.	Proportion of stroke at which steam is cut off.	R.
$\frac{1}{3}$	8	$\frac{3}{10}$	3.33
$\frac{1}{5}$	5	$\frac{4}{10}$	2.5
$\frac{1}{4}$	4	$\frac{6}{10}$	1.66
$\frac{3}{8}$	2.66	$\frac{7}{10}$	1.42
$\frac{1}{2}$	2	$\frac{8}{10}$	1.25
$\frac{5}{8}$	1.6	$\frac{7}{8}$	1.14
$\frac{3}{4}$	1.33	$\frac{9}{10}$	1.11
$\frac{1}{10}$	10		

To find the elastic force in inches of mercury of saturated steam at a given temperature. E = elastic force in inches of mercury; T = temperature Fahrenheit.

$$E = \text{Log. (log. } T + 51.3) - 2.1327940 \times 5.13 + 0.1$$

$$T = \log. \left(\frac{\log. (E - 0.1)}{5.13} + 2.1327940 \right) - 51.3$$

PRESSURE OF STEAM AT DIFFERENT TEMPERATURES.

Results of Experiments made by the Franklin Institute.

Pressure in inches of mercury.	Temperature in degrees Fahr.	Pressure in inches of mercury.	Temperature in degrees Fahr.	Pressure in inches of mercury.	Temperature in degrees Fahr.
30	212°	135	298.5°	225	331°
45	235	150	304.5	240	336
60	250	165	310	255	340.5
75	264	180	315.50	270	345
90	275	195	321	285	349
105	284	210	326	300	352.5
120	291.5				

PRESSURE OF STEAM AT DIFFERENT TEMPERATURES.

Results of Experiments made by the French Academy.

An atmosphere is reckoned as being equal to 29.922 inches of mercury.

Pressure in atmospheres.	Temperature in degrees Fahr.	Pressure in atmospheres.	Temperature in degrees Fahr.	Pressure in atmospheres.	Temperature in degrees Fahr.
1	212°	7½	336.86°	19	413.78°
1½	234	8	341.78	20	418.46
2	250.5	9	350.78	21	422.96
2½	263.8	10	358.88	22	427.98
3	275.2	11	366.85	23	431.42
3½	285	12	374	24	435.56
4	293.7	13	380.66	25	439.34
4½	300.3	14	386.94	30	457 16
5	307.5	15	392.86	35	472.73
5½	314.24	16	398.48	40	486.59
6	320.36	17	403.83	45	499.14
6½	326.26	18	408.92	50	510.6
7	331.7				

TABLE OF STEAM USED EXPANSIVELY.

Initial pressure, lbs. per square inch.	Average pressure of steam in lbs. per square inch for the whole stroke.					
	Portion of stroke at which steam is cut off.					
	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{8}$
5	4.8	4.6	4.2	3.7	3.0	1.9
10	9.6	9.2	8.4	7.4	5.9	3.8
15	14.5	13.8	12.7	11.2	8.9	5.8
20	19.3	18.4	16.9	14.8	11.9	7.7
25	24.1	22.9	21.1	18.6	14.9	9.6
30	29.0	27.5	25.4	22.3	17.9	11.5
35	33.8	32.1	29.6	26.0	20.8	13.5
40	38.6	36.7	33.8	29.7	23.8	15.4
45	43.4	41.3	38.1	33.5	26.8	17.8
50	48.3	45.9	42 3	37.2	29.8	19.2
60	57.9	55.1	50 7	44.6	35.7	23.1
70	67.6	64.3	59.2	52.1	41.7	26.9
80	77.3	73.5	67.7	59.5	47.7	30.8
90	86.9	82.7	76 1	66.9	53.6	34.6
100	96.6	91.9	84.6	74.4	59.6	38.5
110	106.2	101.1	93.1	81.8	65.6	42.3
120	115.9	110.3	101.5	89.3	71 5	46.2
130	125.6	119.4	110.0	96.7	77.5	50.0
140	135.2	128.6	118.5	104.1	83.4	53.9
150	144.9	137.8	126.9	111.6	89.4	57.7
160	154.6	147.0	135.4	119 0	95.4	61.6
180	173.9	165 4	152.3	133.9	107.3	69.3
200	193.2	183.8	169.2	148.8	119.2	77.0

DUTY OF STEAM ENGINES.

The duty of an engine is the work done in relation to the fuel consumed. This can easily be determined when its consumption of coal per actual horse-power per hour is known.

To find the duty of an engine, divide 166.32 by the number of pounds of coal consumed per actual horse-power per hour; the quotient is the duty in millions of pounds.

TO FIND THE HORSE-POWER OF STEAM ENGINES.

Indicated Horse-Power.

A = Area of piston in square inches.
P = Average pressure of steam in lbs. per sq. inch in cylinder.
S = Length of stroke in feet.
R = Number of revolutions per minute.
r = Number of revolutions per second.

$$\text{Indicated horse-power} = \frac{2\,A\,P\,R\,S}{33{,}000} = \frac{2\,A\,P\,r\,S}{550}$$

Nominal Horse-power.

V = Mean velocity of piston in feet per minute.
D = Diameter of cylinder in inches.
S = Stroke of engine in feet.
H = Nominal horse-power of engine.

$$H = \frac{D^2 \sqrt[3]{S}}{15.6} \text{ for high presssure.}$$

$$D = \frac{\sqrt{15.6\,H}}{\sqrt[3]{S}} \qquad V = 128\sqrt[3]{S}$$

$$H = \frac{D^2 \sqrt[3]{S}}{47} \text{ for condensing engines.}$$

$$D = \frac{\sqrt{47\,H}}{\sqrt[3]{S}} \qquad V = 128\sqrt[3]{S}$$

BOILERS.

To find the safe pressure for a single-riveted cylindric boiler.—D = diameter of boiler in inches, S = safe pressure in lbs. per square inch, T = thickness of plate.

$$S = \frac{T \times 8900}{D} \qquad T = \frac{S \times D}{8900}$$

The constant, 8900, is very nearly equal to $\frac{M}{s} = \frac{44,800}{5}$ where M, the maximum tensile strength of boiler plate, is taken at 20 tons per square inch, and $5 = \frac{1}{5}$, the safe strain per square inch.

Strength of plate.....	= 1
Double-riveted joints.....	0.7
Single " "	0.56

For tables of experiments on the strength of iron boiler plates, see "Strength of Materials."

WINDING ENGINES.

According to the second edition of Mr. Greenwell's *Practical Treatise on Mine Engineering*, if it be required to draw 600 tons daily from a shaft, the load, speed and power of engine may be adjusted to the depth as follows :

Depth.	Load.		Speed.	Time of Drawing and Changing.	Power of Engines.		
Fathoms.	Tubs.	Cwts.	Feet per second.	Seconds.	Calculated.	Allowed for friction, &c.	Total.
50	2 =	16	10	40	33	17	50
75	2	16	14	40	45	22	67
100	2	16	18	40	58	29	87
125	3	24	15	70	74	37	111
150	3	24	18	70	88	44	132
175	3	24	21	70	102	51	153
200	3	24	24	70	117	58	175
225	3	24	27	70	132	66	198
250	3	24	30	70	146	73	219
275	4	32	24	90	157	78	235
300	4	32	25	90	169	84	253
325	4	32	28	90	182	91	273
350	4	32	30	90	196	98	294
375	4	32	32	90	208	194	312
400	4	32	34	90	220	110	330

PUMPING ENGINES.

The *power* required for pumping, according to Tredgold, is found by taking the exact height from the surface of the water to the point of discharge—adding $1\frac{1}{2}$ ft. for each lift for the force required to give the water the velocity, and also $\frac{1}{20}$th of the height for the friction of the piston. Call this quantity in feet H, and the diameter of pump A, in inches, then

$$.341\ H\ A^2 = \text{Load in lbs.}$$

whence if P = mean effective force on the steam piston in lbs. per circular inch, we have

$$D = A\left(\frac{.341\ H}{P}\right)^{\frac{1}{2}}$$

the diameter of piston in inches.

To find the quantity of water which an engine will pump from a given depth, multiply the horse-power by 550, and divide the product by the depth of pit in fathoms; or

Let H = Horse-power of engine
F = Depth of pit in fathoms
G = Quantity of water in gallons per minute

Then $G = \frac{H \times 550}{F}$

$F = \frac{H \times 550}{G}$

$H = \frac{F \times G}{550}$

Rule for calculating the quantity of water drawn at a single stroke in a working barrel of a given diameter:—Square the diameter in inches, and divide by 10, for the gallons in a 3-ft. stroke.

The accompanying table, illustrating the duty of pumping engines, is taken from a paper by Mr. J. B. Simpson, read before the North of England Institute of Mining and Mechanical Engineers ("*Transactions*," vol. xix., p. 201, &c.)

TABLE SHOWING QUANTITY OF WATER IN IMPERIAL GALLONS, DELIVERED BY A PUMP AT EACH STROKE OF THE ENGINE.

Dia. of Pump, in Ins.	LENGTH OF STROKE.					
	1 ft. 6 in.	2 ft.	2 ft. 6 in.	3 ft.	3 ft. 6 in.	4 ft.
3	0.46	0.61	0.76	0.91	1.06	1.22
4	0.82	1.09	1.36	1.63	1.90	2.17
5	1.27	1.70	2.12	2.55	2.97	3.40
6	1.84	2.44	3.05	3.67	4.28	4.89
7	2.50	3.33	4.16	4.99	5.82	6.66
8	3.26	4.35	5.43	6.52	7.61	8.70
9	4.13	5.50	6.88	8.26	9.63	11.01
10	5.10	6.80	8.50	10.20	11.90	13.60
11	6 17	8.22	10.27	12.33	14.39	16.45
12	7.34	9.79	12.23	14.68	17.13	19.58
13	8.61	11.49	14.36	17.23	20.10	22.98
14	9.99	13.32	16.65	19.97	23.31	26.65
15	11.47	15.29	19.11	22.94	26.76	30.59
16	13.05	17.40	21.76	26.11	30.46	34.81
17	14.73	19.65	24.56	29.47	34.38	39 30
18	16.52	22.02	27.53	33.04	38.54	44.05
19	18.40	24.54	30.67	36.81	42.94	49.08
20	20.39	57.19	33.99	40.79	47.59	54.39
21	22.48	29.98	37.47	44.97	52.46	59.96
22	24.68	32.90	41.13	49.36	57.59	65.81
23	26.97	35.96	44.95	53.94	62.93	71.93
24	29.37	39.16	48.95	58.74	68.53	78.32
25	31.87	42.49	53.11	63.73	74.35	84.98
26	34.47	45.96	57.45	68.94	80.43	91.92
27	37.17	49.56	61.95	74.34	86.73	99.13
28	39.97	53.30	66.62	79.95	93.28	106.61
29	42.88	57.18	71.47	85.77	100.06	114.36
30	45.89	61.19	76.48	91.78	107.08	122.38
31	49.00	65.33	81.66	98.00	114 33	130.67
32	52.21	69.62	87 02	104 43	121.83	139.24
33	55.53	74.04	92.55	111.06	129.57	148.08
34	58.94	78.59	98.24	117.89	137.54	157.19
35	62.46	83.28	104.10	124.93	145.75	166.57
36	66.08	88.11	110.13	132.16	154.19	176.22

TABLE SHOWING QUANTITY OF WATER IN IMPERIAL GALLONS, DELIVERED BY A PUMP AT EACH STROKE OF THE ENGINE (*continued*).

Dia. of Pump, in Ins.	LENGTH OF STROKE.					
	4 ft. 6 in.	5 ft.	5 ft. 6 in.	6 ft.	6 ft. 6 in.	7 ft.
3	1.37	1.52	1.68	1.83	1.97	2.13
4	2.44	2.72	2.99	3.26	3.53	3.80
5	3.82	4.25	4.67	5.10	5 52	5 95
6	5.50	6.11	6.73	7.34	7.95	8.56
7	7.49	8.32	9.16	9.99	10.81	11.65
8	9 78	10.87	11.96	13.05	14.13	15.22
9	12.38	13.76	15.14	16.52	17.89	19.27
10	15.30	17.00	18.70	20.40	22.10	23.80
11	18.50	20.55	22.62	24.67	26.72	28.78
12	22.02	24.47	26.92	29.37	31.81	34.26
13	25.85	28.72	31.59	34.47	37.33	40.21
14	29.97	33.30	36.64	39.97	43.29	46.63
15	34.41	38.23	42.06	45.89	49.70	53.53
16	39.16	43 51	47.86	52.22	56.57	60.92
17	44.21	49.12	54.03	58.95	63.85	68.77
18	49.55	55.06	60.57	66.08	71.58	77.09
19	55.21	61.35	67.48	73.62	79.75	85.89
20	61 18	67.98	74.78	81.58	88.38	95.18
21	67 45	74.95	82 44	89.94	97.43	104.93
22	74.03	82.26	90.49	98.72	106.95	115 17
23	80.91	89.90	98.90	107.89	116.87	125.87
24	88.11	97.90	107.69	117.48	127.27	137.06
25	95.60	106.22	116.85	127.47	138.08	148.71
26	103.41	114.90	126.39	137.88	149.37	160.86
27	111.51	123.90	136.30	148.69	161.07	173.47
28	119.93	133.25	146.58	159.91	173.23	186.56
29	128.65	142.95	157.24	171.54	185.83	200.13
30	137.67	152.97	168.27	183.57	198.86	214.16
31	147.00	163.33	179.67	196.01	212.33	228 67
32	156.64	174.05	191.45	208.86	226.26	243.67
33	166.59	185.10	203.61	222.12	240.63	259.14
34	176.83	196.48	216.13	235.79	255.43	275.08
35	187.39	208.21	229.03	249.86	270.68	291.50
36	198.24	220.27	242.30	264.33	286.36	308 38

TABLE SHOWING QUANTITY OF WATER, IN IMPERIAL GALLONS, DELIVERED BY A PUMP AT EACH STROKE OF THE ENGINE (*Continued*).

Dia. of Pump in Ins.	LENGTH OF STROKE.					
	7 ft. 6 ins.	8 ft.	8 ft. 6 ins.	9 ft.	9 ft 6 ins.	10 ft.
3	2.28	2.45	2.59	2.74	2.89	3.06
4	4.07	4.35	4.61	4.89	5.16	5.44
5	6.37	6.80	7.22	7.65	8.07	8.50
6	9.17	9.79	10.39	11.00	11.61	12.23
7	12.48	13 32	14.15	14.98	15.81	16.65
8	16.31	17.40	18.48	19.57	20.65	21.75
9	20.64	22.03	23.39	24 77	26.14	27.53
10	25.50	27.20	28.90	30.60	32.30	34.00
11	30.84	32.90	34.95	37.00	39.05	41.12
12	36.71	39.16	41.60	44.05	46.49	48.95
13	43.08	45.96	48.83	51.70	54.57	57.45
14	49.96	53 30	56.62	59.95	63.27	66.62
15	57.35	61.19	65.00	68.82	72.64	76.48
16	65.27	69.62	73.97	78.32	82 67	87.02
17	73.68	78.60	83.51	88.42	93.33	98.25
18	82.59	88 11	93.60	99.11	104.61	110.13
19	92.01	98.17	104.29	110.43	116.56	122.71
20	101.98	108.78	115 57	122.37	129.16	135.97
21	112.42	119.93	127.41	134.91	142.40	149.91
22	123.40	131.63	139.84	148.07	156.29	164.53
23	134.86	143.86	152.84	161.83	170.81	179.82
24	146 85	156.65	166.43	176.22	186.01	195.81
25	159.33	169.97	180.58	191.22	201.82	212.46
26	172 35	183.85	195.33	206.82	218.31	229 81
27	185.86	198.26	210.64	223.03	235.41	247.82
28	199.89	213.22	226.54	239.86	253.18	266.52
29	214.42	228.72	243.01	257.31	271.16	285.90
30	229.46	244.76	260.05	275.35	290.64	305.95
31	245.00	261.35	277.67	294.00	310.33	326.68
32	261.07	278.48	295.88	313.29	330.69	348.10
33	277.65	296 16	314.67	333.18	351.69	370.20
34	294.73	314.39	334.02	353.67	373.31	392.98
35	312.32	333.15	353.96	374.78	395.60	416.43
36	330.41	352.44	374.46	396.49	418.51	440.55

WATER.

TO FIND THE WEIGHT OF WATER IN PIPES OF ANY DIAMETER 1 FOOT LONG.

1st. Square the diameter in inches, and divide by 3.

2d (more correctly). Square the diameter in inches, and multiply by .34.

In the two following tables the weight of water has been reckoned at 10 lbs. per gallon.

TABLE OF THE WEIGHT OF WATER CONTAINED IN A FATHOM OF PIPES OF ANY DIAMETER; ALSO THE NUMBER OF GALLONS.

Diameter in inches.	Weight in Lbs.	No. of Gallons.
½	0 51	.051
1	2.0	.20
2	8.1	.81
3	18 3	1.83
4	32.6	3.26
5	51.0	5.10
6	73.4	7.34
7	99.9	9.99
8	130.5	13.05
9	165.2	16.52
10	204.0	20.40
11	246.8	24.68
12	293.7	29.37
13	344.7	34.47
14	399.8	39.98
15	459.0	45.90
16	522.2	52.22
17	589.5	58.95
18	660 9	66.09
19	736.4	73 64
20	816.0	81 60
21	899.6	89.96
22	987.3	98.73
23	1079.1	107.91
24	1175.0	117.50

The following simple rule will be found useful to ascertain the weight of water in pipes:—Square the diameter in inches; the result will be the weight in pounds avoirdupois in a 3-ft. length.

TABLE SHOWING THE WEIGHT IN POUNDS, AND MEASURE IN GALLONS, OF WATER CONTAINED IN WELLS AND PITS OF ANY DIAMETER, FOR 1 FOOT IN DEPTH.

NOTE.—The number of gallons is found by squaring the diameter in feet, and multiplying by 4.895 (the number of gallons in a cylinder 1 ft. diameter and 1 ft deep).

Diameter. Ft. in.	Measure in Gallons.	Weight in Lbs.
2 0	19.580	195.80
2 6	30.594	305.94
3 0	44.055	440.55
3 6	60.964	609.64
4 0	78.320	783.20
4 6	99.124	991.24
5 0	122.375	1,223.75
6 0	176.220	1,762.20
7 0	239.855	2,398.55
8 0	313.280	3,132.80
9 0	396.495	3,964.95
10 0	489.500	4.895.00
11 0	592.295	5,922.95
12 0	704.880	7,048.80
13 0	827.255	8,272.55
14 0	959.420	9,594.20
15 0	1101.375	11,013.75
16 0	1253.120	12.531.20
17 0	1414.655	14,146.55
18 0	1585.980	15,859.80
19 0	1767.095	17,670.95
20 0	1958.000	19,580.00

TO ASCERTAIN THE NUMBER OF IMPERIAL GALLONS CONTAINED IN ANY CISTERN,

THE CUBIC CONTENTS HAVING BEEN FOUND.

Contents in cubic feet $\times$ 6.232

Or, contents in cubic inches $\times$ .003607

Or, $\frac{\text{contents in cubic inches}}{277.274}$

TO ASCERTAIN THE PRESSURE OF WATER IN PIPES AT VARIOUS DEPTHS.

RULE 1.

$$\frac{\text{Head of water in feet} \times 62.5}{144} = \text{pressure in lbs. per sq. in.}$$

RULE 2.

$$\frac{\text{Head of water in feet} \times 62.5}{2240} = \text{pressure in tons per sq. ft.}$$

EXAMPLE 1.—What is the pressure per square inch on a pipe having a head of water of 30 feet?

$$\frac{30 \times 62.5}{144} = 13.02 \text{ lbs.}$$

EXAMPLE 2.—What is the pressure per square foot on a pipe having a head of water of 120 feet?

$$\frac{120 \times 62.5}{2240} = 3.34 \text{ tons.}$$

As it has been found by experiment that a cast-iron pipe 15 inches diameter, $\frac{3}{4}$ in. thick, will be sufficiently strong for a head of 600 ft., the following rule is given to ascertain the thickness of metal in a pipe, when its diameter and the head of water are given.

$$\frac{\text{Head of water in ft.} \times \text{size of pipe in in.} \times \frac{3}{4}}{9000} = \text{thickness of metal in inches.}$$

TABLE SHOWING THE PRESSURE ON PIPES WITH VARIOUS HEADS OF WATER.

Height of Water, in Feet.	Pressure per Sq. in., in Lbs.	Pressure per Sq. ft., in Tons.
20	8.68	0.55
25	10.85	0.69
30	13.02	0.83
35	15.19	0.97
40	17.35	1.11
45	19.53	1.25
50	21.70	1.39
55	23.87	1.53

TABLE SHOWING THE PRESSURE ON PIPES WITH VARIOUS HEADS OF WATER (*continued*).

Height of Water, in Feet.	Pressure per Sq. in., in Lbs.	Pressure per Sq. foot, in Tons.
60	26.04	1.67
65	28.21	1 81
70	30.37	1.95
75	32.55	2.09
80	34.72	2.23
85	36.89	2.37
90	39.06	2.51
95	41.23	2.65
100	43.40	2.79
105	45.57	2.92
110	47.74	3.06
115	49.91	3.20
120	52.08	3.34
125	54.25	3.48
130	56.42	3.62
135	58.59	3.76
140	60.76	3.90
145	62.93	4.04
150	65.10	4.18
160	69.44	4.46
170	73.78	4.73
180	78.13	5.02
190	82.46	5.30
200	86.80	5.58
210	91.14	5.85
220	95.48	6.13
230	99.82	6.41
240	104.16	6.69
250	108.50	6.97
260	112.84	7.25
270	117.18	7.53
280	121.52	7.81
290	125.86	8.09
300	130.20	8.37
310	134.54	8.64
320	138.88	8.92
330	143.22	9.20
340	147.56	9.48
350	151.90	9.76

TABLE SHOWING THE PRESSURE ON PIPES WITH VARIOUS HEADS OF WATER (*continued*).

Height of Water, in Feet.	Pressure per Sq. in., in Lbs.	Pressure per Sq. foot, in Tons.
360	156.25	10.04
370	160.59	10.32
380	164.93	10.60
390	169.27	10.88
400	173.61	11.16
410	177.95	11.43
420	182.29	11.71
430	186.63	11.99
440	190.97	12.27
450	195.31	12.55
460	199.65	12.83
470	203.99	13.11
480	208.33	13.39
490	212.67	13.67
500	217.01	13.95
600	260.41	16.74

FRICTION OF WATER IN PIPES.

Comparison of Boulton and Watt's and Weisbach's Formula.

For Velocities of 2 feet per second.

Diameter of Pipe in Inches.	Head in feet per mile required to balance Friction. By Boulton & Watt.	By Weisbach.
3	36.00	34.79
6	18.00	17.37
12	9.00	8.71
24	4.50	4.33

For Velocities of 3 feet per second.

3	81.00	71.28
6	40.50	35.85
12	20.25	17.89
24	10.12	8.98

For Velocities of 7 feet per second.

3	441.00	335.28
6	220.50	197.90
12	110.25	83.95
24	55.12	41.92

STRENGTH OF MATERIALS.

ROPES AND CHAINS.

Cohesion of hemp fibres = 6400 lbs. per square inch of transverse section. For *safe load*, multiply the square of the girth by 200, and the product will be the strain in lbs. For cables ×120 instead of 200. For *utmost strength*, take one-fifth of the square of the girth to express the tons it will carry. Tarred cordage is always weaker than white; for, according to Du Hamel, white is one-third more durable, retains its force much longer while kept in store, and resists the ordinary injuries of the weather one-fourth longer.—(*Gregory.*) The greatest stress on a rope should not be above 700 times its weight per fathom.—(*Tredgold.*)

The mean of a variety of Ropemaker's Cards gives the following approximate rule:—

	Breaking strain:
For hemp ropes (flat or round)...	1 ton
" iron wire ropes, nearly.....	2 tons
" steel wire ropes, nearly	3 tons

} for each lb. per fathom.

The working load is from one-fifth to one-seventh of breaking strain.

WEIGHT AND STRENGTH OF FLAT ROPES.

Steel Wire.		Iron Wire.		Hemp of Equiv't Strength			
Size in inches.	Wght per fath.	Size in inches.	Wght per fath.	Size in inches.	Wght per fath.	Working load.	Breaking strain.
Inches.	Lbs.	Inches.	Lbs.	Inches.	Lbs.	Cwts.	Tons.
$3\frac{1}{4}$ by $\frac{5}{8}$	18	$4\frac{1}{2}$ by $\frac{7}{8}$	30	$8\frac{1}{2}$ by $2\frac{1}{4}$	45	120	46
3 " $\frac{5}{8}$	16	$4\frac{1}{4}$ " $1\frac{3}{16}$	27	$7\frac{1}{2}$ " $2\frac{1}{8}$	40	108	40
$2\frac{7}{8}$ " $\frac{9}{16}$	14	4 " $\frac{3}{4}$	24	7 " $1\frac{7}{8}$	36	96	36
....		$3\frac{3}{4}$ " $\frac{3}{4}$	22	$6\frac{1}{2}$ " $1\frac{5}{8}$	32	88	32
$2\frac{3}{4}$ " $\frac{1}{2}$	$12\frac{1}{2}$	$3\frac{1}{2}$ " $1\frac{1}{16}$	20	6 " $1\frac{1}{2}$	28	80	28
....		$3\frac{1}{4}$ " $\frac{5}{8}$	18	$5\frac{3}{4}$ " $1\frac{1}{2}$	27	72	27
2 " $\frac{5}{8}$	10	3 " $\frac{5}{8}$	16	$5\frac{1}{2}$ " $1\frac{3}{8}$	26	64	26
$1\frac{1}{8}$ " $\frac{1}{2}$	8	$2\frac{7}{8}$ " $\frac{9}{16}$	14	$5\frac{1}{4}$ " $1\frac{1}{4}$	24	56	24
....		$2\frac{3}{4}$ " $\frac{1}{2}$	12	5 " $1\frac{1}{4}$	22	48	22
....		2 " $\frac{5}{8}$	10	4 " $1\frac{1}{8}$	20	40	20
....		$1\frac{7}{8}$ " $\frac{1}{2}$	8	3 " 1	16	32	16

TABLE OF THE WEIGHT AND STRENGTH OF CHAIN.

Diameter. Inches.	Weight per fathom Lbs.	Proof Strength Tons.	Diameter. Inches.	Weight per fathom Lbs.	Proof strength Tons.
$0\frac{5}{16}$	$5\frac{1}{2}$	1.27	$1\frac{3}{16}$	76	29
$0\frac{3}{8}$	8	1.83	$1\frac{1}{4}$	84	32
$0\frac{7}{16}$	$10\frac{1}{2}$	2.5	$1\frac{5}{16}$	93	35
$0\frac{1}{2}$	$13\frac{3}{4}$	4	$1\frac{3}{8}$	102	38
$0\frac{9}{16}$	17	5	$1\frac{7}{16}$	111	41
$0\frac{5}{8}$	22	6	$1\frac{1}{2}$	120	44
$0\frac{11}{16}$	26	7.25	$1\frac{9}{16}$	128	48
$0\frac{3}{4}$	30	10	$1\frac{5}{8}$	136	52
$0\frac{13}{16}$	36	11 5	$1\frac{11}{16}$	142	56
$0\frac{7}{8}$	42	13	$1\frac{3}{4}$	148	60
$0\frac{15}{16}$	49	15	$1\frac{13}{16}$	150	65
1	55	18	$1\frac{7}{8}$	162	70
$1\frac{1}{16}$	60	22	$1\frac{15}{16}$	171	75
$1\frac{1}{8}$	68	26	2	180	80

TO FIND THE BREAKING STRAIN OF HEMP ROPES.

$$\text{Breaking weight in tons} = \frac{\text{circumference squared in ins.}}{4}$$

Example.—What is the breaking weight of a rope 8 inches in circumference?

$$\frac{8 \times 8}{4} = 16 \text{ tons.}$$

To find the weight which may be safely appended to a hemp rope:—

$$W = \frac{\text{circumference squared in inches}}{10}$$

Example.—What weight might be safely appended to a hemp rope 10 inches in circumference?

$$\frac{10^2}{10} = 10 \text{ tons.} \quad \text{Answer.}$$

HOW TO USE WIRE ROPE.

Wire ropes used for hoisting are manufactured with 19 wires to the strand. They are made with 6 strands, with a centre of hemp or wire, the former being more

pliable, and will wear better over small pulleys and drums. They are made of iron or steel, and sometimes up to three inches in diameter.

In the machinery for wire rope the drums and sheaves should be made as large as possible. Wire rope is as pliable as new hemp rope of the same strength, and can be used on the same sized sheaves and pulleys, but the greater the diameter of the sheaves, pulleys or drums, the longer wire rope is found to wear. It is found that the wear increases with the speed. It is therefore better to increase the load than the speed.

It injures wire rope to coil or uncoil it like hemp rope. All untwisting or kinking should be avoided. When not on a reel, it should be rolled on the ground like a wheel, to prevent kinking. Raw linseed oil applied with a piece of sheepskin, wool inside, will preserve wire rope. The oil can be mixed with equal parts of Spanish brown or lamp black When the wire is under water or under ground, take mineral or vegetable tar, and add one bushel of fresh slacked lime to one barrel of tar, which will neutralize the acid. Boil well, and add saw dust to give the mixture body, and then saturate the rope with it.

Steel ropes are, to some extent, taking the place of iron ropes, where lightness combined with strength is required. In substituting a steel rope for an iron running rope, the object in view should be rather to increase the wear rather than to reduce the size. A safe working load is from one-fifth to one-seventh of the ultimate strength, according to speed. When wire ropes are substituted for hemp ropes, the same weight per foot should be allowed for the former as experience has approved for the latter.

The grooves of cast iron pulleys and sheaves should be filled with well-seasoned blocks of hard wood set on end, to be renewed when worn out. This end wood will save wear and increase adhesion. The smaller pulleys or rollers, which support the ropes on inclined planes, should be constructed on the same plan. When large sheaves run with very great velocity, the grooves should be lined with leather, set on end, or with India rubber. This is done in the case of all sheaves used in the *transmission of power* between distant points by means of rope, which frequently run at the rate of 4,000 feet per minute.

The following tables show the different sizes and weights of hoisting rope manufactured by the principal manufacturers :

STANDARD HOISTING ROPES WITH 19 WIRES TO THE STRAND.

Iron.

Trade No.	Circumference in inches.	Diameter.	Weight per ft. in lbs. of Rope with Hemp Cen.	Breaking strain in tons of 2,000 pounds.	Proper working load in tons of 2,000 pounds.	Circumference of Hemp Rope of equal strength.	Min. size of drum or sheave in feet.
1	$6\frac{3}{4}$	$2\frac{1}{4}$	8.00	74	15	$15\frac{1}{2}$	8
2	6	2	6.30	65	13	$14\frac{1}{2}$	7
3	$5\frac{1}{2}$	$1\frac{3}{4}$	5.25	54	11	13	$6\frac{1}{2}$
4	5	$1\frac{5}{8}$	4.10	44	9	12	5
5	$4\frac{3}{4}$	$1\frac{1}{2}$	3.65	39	8	$11\frac{1}{2}$	$4\frac{3}{4}$
6	4	$1\frac{1}{4}$	2.50	27	$5\frac{1}{2}$	$9\frac{1}{2}$	4
7	$3\frac{1}{2}$	$1\frac{1}{8}$	2.00	20	4	8	$3\frac{1}{2}$
8	$3\frac{1}{8}$	1	1.58	16	3	7	3
9	$2\frac{3}{4}$	$\frac{7}{8}$	1.20	$11\frac{1}{2}$	$2\frac{1}{2}$	6	$2\frac{3}{4}$
10	$2\frac{1}{4}$	$\frac{3}{4}$	0.88	8.64	$1\frac{3}{4}$	5	$2\frac{1}{2}$
$10\frac{1}{4}$	2	$\frac{5}{8}$	0.70	5.13	$1\frac{1}{4}$	$4\frac{1}{2}$	2
$10\frac{1}{2}$	$1\frac{5}{8}$	$\frac{9}{16}$	0.44	4.27	$\frac{3}{4}$	4	$1\frac{3}{4}$
$10\frac{3}{4}$	$1\frac{1}{2}$	$\frac{1}{2}$	0.35	3.48	$\frac{1}{2}$	$3\frac{1}{2}$	$1\frac{1}{2}$

Cast Steel.

1	$6\frac{3}{4}$	$2\frac{1}{4}$	8.00	130	26		9
2	6	2	6.30	100	21		8
3	$5\frac{1}{2}$	$1\frac{3}{4}$	5.25	78	17	$15\frac{3}{4}$	$7\frac{1}{2}$
4	5	$1\frac{5}{8}$	4.10	64	13	$14\frac{1}{2}$	6
5	$4\frac{3}{4}$	$1\frac{1}{2}$	3.65	55	11	$13\frac{1}{2}$	$5\frac{1}{2}$
6	4	$1\frac{1}{4}$	2.50	39	8	$11\frac{1}{2}$	5
7	$3\frac{1}{2}$	$1\frac{1}{8}$	2.00	30	6	10	$4\frac{1}{2}$
8	$3\frac{1}{8}$	1	1.58	24	5	$9\frac{1}{4}$	4
9	$2\frac{3}{4}$	$\frac{7}{8}$	1.20	20	4	8	$3\frac{3}{4}$
10	$2\frac{1}{4}$	$\frac{3}{4}$	0.88	13	3	$6\frac{1}{2}$	$3\frac{1}{2}$
$10\frac{1}{4}$	2	$\frac{5}{8}$	0.70	9	2	$5\frac{1}{4}$	3
$10\frac{1}{2}$	$1\frac{5}{8}$	$\frac{9}{16}$	0.44	$6\frac{1}{2}$	$1\frac{1}{2}$	$4\frac{3}{4}$	$2\frac{3}{4}$
$10\frac{3}{4}$	$1\frac{1}{2}$	$\frac{1}{2}$	0.35	$5\frac{1}{2}$	1	$4\frac{1}{2}$	2

Note.—The weight of Wire Centre Ropes is 10 per cent. more than that of Ropes with Hemp Centres.

TO FIND THE ULTIMATE TRANSVERSE STRENGTH OF BEAMS.

1.—Beam supported at both ends, and loaded in middle:

Let L = length in inches.
B = breadth "
D = depth "
W = breaking weight in lbs.

M = { 1672 for English Oak.
1556 " beech.
1013 " elm.
1632 " pitch pine.
1341 " red pine.
900 " larch.
9000 " wrought iron.
6000 " cast iron. }

$$W = \frac{D^2 \times B \times 4 \times M}{L}; \text{ or } W = \frac{4\,D \times B\,D \times M}{L}.$$

These rules show how to find the weight that will BREAK the beams; when the weight that may be safely placed upon them is not more than one-third for a steady, or one-sixth for a moving or suddenly applied load; and in the case of timber, beams that have to bear a permanent load should not be more than one-tenth, in order to allow for the effect of decay.

STRENGTH OF ROLLED IRON BEAMS.

B W = Breaking weight distributed in tons.

Depth of beam. Inches.	Size of flange. In. In.	B. W. FOR DIFFERENT SPANS. 10 ft.	15 ft.	20 ft.	25 ft.
5	2 × ½	6.6	—	—	—
6	2½ × ½	10	6.6	5	—
7	3 × ½	14	9	7	5
8	3 × ⅝	20	13	10	8
9	4 × ¾	36	24	18	14
10	4½ × 1	60	40	30	24

STRENGTH OF COLUMNS.

TABLE OF PRACTICAL FORMULA BY WHICH TO DETERMINE THE AMOUNT OF WEIGHT A COLUMN OF GIVEN DIMENSIONS WILL SUPPORT, IN POUNDS.

For a rectangular column of cast iron.... $W = \frac{15300\, l\, b^3}{4\, b^2 + .18\, l^2}$

For a rectangular col. of malleable iron, $W = \frac{17800\, l\, b^3}{4\, b^2 + .16\, l^2}$

For a rectangular column of oak..... $W = \frac{3960\, l\, b^3}{4\, b^2 + .5\, l^2}$

For a solid cylinder of cast iron..... $W = \frac{9562\, d^4}{4\, d^2 + .18\, l^2}$

For a solid cylinder of malleable iron.... $W = \frac{11125\, d^4}{4\, d^2 + .16\, l^2}$

For a solid cylinder of oak..... $W = \frac{2470\, d^4}{4\, d^2 + .5\, l^2}$

NOTE.—W = the weight the column will support in lbs.; b = the breadth in inches; l = the length in feet; d = the diameter in inches.

APPROXIMATE RULE FOR THE STRENGTH OF RECTANGULAR PILLARS OF WOOD. (*Molesworth.*)

L = Length of pillar.
B = Breadth of ditto.
W = Crushing weight in lbs. per square inch of section.

Safe load per square inch of sectional area = $\frac{W}{10}$.

Material.	Values of W when L. or Length. =				
	8 B.	12 B.	24 B.	36 B.	48 B.
Oak	5500	4600	2700 ...	1800 ...	900
Ash	6000 ...	5000	3000	2000 ...	1000
Red pine.....	4800 ...	4000 ...	2400	1600	800

RELATIVE STRENGTH OF MATERIALS IN LONG COLUMNS.

Cast Iron being assumed as	= 1000
Wrought Iron	= 1745
Cast Steel	= 2518
Oak	= 109
Red Deal	= 78½

RELATIVE STRENGTH OF ROUND AND FLAT ENDS IN LONG COLUMNS.

Both ends rounded, 1 strength	= 1
One end flat and firmly fixed, 1 strength	= 2
Both ends flat and firmly fixed	= 3

RELATIVE STRENGTH OF SECTION IN LONG SOLID COLUMNS.

Cylindrical	100
Triangular	110
Square	93

HOLLOW COLUMNS.

The strength nearly equals the difference between that of two solid columns the diameters of which are equal to the external and internal diameters of the hollow one.

RELATIVE BREAKING WEIGHT PER SQUARE INCH OF WROUGHT AND CAST IRON PILLARS.

		Wrought Tons.	Cast Tons.
Ratio of least thickness to height	$\frac{1}{10}$	15.5	28.6
" " "	$\frac{1}{20}$	14.2	17.9
" " "	$\frac{1}{26 \cdot 4}$	13.0	13.0
" " "	$\frac{1}{30}$	12.4	11.0
" " "	$\frac{1}{40}$	10.5	7.1

SAFE LOAD FOR HOLLOW CAST IRON PILLARS.

Thickness of metal.	External diameter. Inches.	LENGTH OF PILLAR. 8 ft. Tons.	10 ft. Tons.	12 ft. Tons.	14 ft. Tons.	16 ft. Tons.
½ in.	3	4.0	3.2	2.3	1.8	1.4
	3½	5.9	5.1	3.6	2.7	2.3
	4	8.1	6.1	4.7	3.6	3.4
	4½	10.6	8.1	6.5	5.0	4.4
	5	13.3	10.4	8.3	6.7	5.4
	5½	15.3	12.9	10.5	8.5	7.0
	6	19.0	15.5	12.7	9.5	8.7
⅝ in.	3	4.7	3.5	2.6	2.0	1.6
	3½	7.1	5.3	4.2	3.2	2.5
	4	9.2	7.3	5.6	4.4	3.9
	4½	12.8	9.9	7.7	6.1	5.5
	5	16.1	12.7	9.1	8.1	7.0
	5½	18.7	15.7	12.8	10.4	8.8
	6	23.2	19.0	15.6	12.8	10.6
	6½	86.9	22.4	18.7	15.2	13.0
	7	30.7	26.0	21.9	18.5	15.6
¾ in.	3	5.4	3.8	2.8	2.2	1.7
	3½	8.1	6.2	4.4	3.5	2.6
	4	11.3	8.5	6.5	4.8	3.8
	4½	14.9	11.5	8.9	7.2	6 0
	5	18.8	14.8	11.7	9.9	7.7
	5½	21.8	18.4	14.9	12.1	10.2
	6	27.2	22.3	18.3	15.0	12.5
	6½	31.6	26.3	21.9	17.8	15.3
	7	36.1	30.6	25.8	21.7	18.4
1 in.	4	13.9	10.4	8.0	6.4	4.8
	4½	18.5	14.3	11.1	8.8	7.1
	5	23.6	18.6	14.8	11.9	9.6
	5½	27.6	23.2	18.9	15.3	12.7
	6	34.5	28.3	23.2	19.1	15.9
	6½	40.3	33.6	28.0	22.8	19.6
	7	46.2	39.1	33.0	27.8	23.6
	7⅛	52.2	44.9	38.3	32.6	27.9
	8	58.3	50.7	43.8	37.7	32.5
	8½	64.3	56.5	49.4	42.9	37.3
	9	70.5	62.7	55.3	48.1	42.3

TABLE OF THE RESISTANCE OF MATERIALS TO CRUSHING BY A DIRECT THRUST.

IN POUNDS AVOIRDUPOIS PER SQUARE INCH. (*Rankine*).

Materials.	Resistance to crushing.
Brick	1,100
" Fire	1,700
Chalk	330
Granite	5,500 to 11,000
Limestone, Marble	5,500
Sandstone, ordinary	3,300 to 4,400

(*Rubble masonry, about four-tenths of cut stone.*)

Brass, Cast		10,300
Iron, Cast, various qualities		82,000 to 145,000
" Wrought		about 36,000 to 40,000
Ash	crushed along the grain,	9,000
Beech	do.	9,360
Birch	do.	6,400
Box	do.	10,300
Elm	do.	10,300
Red Pine	do.	5,375 to 6,200
American Yellow Pine	do.	5,400
Lignumvitæ	do.	9,900
Mahogany	do.	8,200
Oak, British	do.	10,000
" Dantzic	do.	7,700
" American Red	do.	6,000

NOTE.—The resistances stated are for DRY timber. Green timber is much weaker, having sometimes only half the strength of dry timber against crushing.

TABLE OF THE RESISTANCE OF MATERIALS TO BREAKING ACROSS.

In Pounds Avoir. per Sq. Inch. (*Rankine.*)

Note.—The modulus of rupture is eighteen times the load which is required to break a bar of one inch square, supported at two points one foot apart, and loaded in the middle between the points of support.

Materials.	Resistance to breaking or modulus of rupture.
Sandstone	1,100 to 2,360
Slate	5,000
Iron, cast, open-work beams, average	17,000
Iron, cast, solid	40,000
Ash	12,000 to 14,000
Beech	9,000 to 12,000
Birch	11,700
Elm	6,000 to 9,700
Red Pine	7,100 to 9,540
Spruce	9,900 to 12,300
Lignum Vitæ	12,000
Oak, British and Russian	10,000 to 13,600
" Dantzic	8,700
" American Red	10,600
Sycamore	9,600

GREATEST SAFE LOAD, PER SUPERFICIAL FOOT.

On Granite piers is	40 tons.
Portland stone piers	13 "
Bath " "	8 "
Brickwork in cement	3 "
Rubble masonry	2 "
Lime concrete foundation	$2\frac{1}{2}$ "

[The height of brick or stone piers should never exceed 12 times their least thickness at base.]

NOTES ON STRENGTH OF MATERIALS.

(*From Molesworth.*)

Wet timber is not so strong as dry; in some cases it is not half the strength of dry.

Cold-blast iron is stronger than hot-blast.

Annealing cast-iron diminishes its tensile strength.

Re-melting (up to ten or twelve meltings) or prolonged fusion, increases the strengh and density of cast iron. Softer irons will best bear re-melting.

Indirect strains reduce the tensile strength of cast iron.

Additional strength should be given to cast iron girders that take the load on one side of the bottom flange.

The tenacity of cast iron is only one-third that of wrought iron, and should not be subjected to more than one-sixth of the breaking strain.

Tensile strain on wrought iron should not exceed one-fourth of the breaking weight.

Annealing iron wire diminishes its strength.

High temperature in casting is injurious to gun-metal.

Plated webs are more economical than braced webs in shallow girders, or near the ends of long girders. In small lattice girders it is better to make the lattices uniform throughout.

SPECIFIC GRAVITY, WEIGHT AND PROPERTIES OF MATERIALS, &c.

The specific gravity of a body is its weight in proportion to an equal bulk of pure water, at a standard temperature. The standard temperature is 62° Fahr. = 16.670 Cent. A cubic inch of water weighs 252.456 troy grains, the temperature being 62° Fahr., and the height of the barometrical column 30 inches; and 7,000 troy grains are equivalent to one pound avoirdupois. Thence it follows that a cubic foot of water would weigh 997.136 ounces.

To find the specific gravity of a *solid heavier than water:* Weigh the body both in air and in water; to the weight in air annex 3 ciphers, and divide by the difference of weight.

To find the specific gravity of a *solid lighter than water:* Attach to it another body heavy enough to sink it, weigh severally the compound mass, and the heavier body in air and water, and say: As the difference of weights lost in water is to the weight of the given body in air, so is the specific gravity of water to that of the given body.

To find the specific gravity of a *fluid:* Weigh both in and out of the fluid a solid (insoluble) of known specific gravity; then say: As the weight of the solid to that lost in the fluid, so is the specific gravity of the former to that of the latter.

The weight of a cubic foot of water at a temperature of 60° is 1000 ounces avoirdupois, and the specific gravity of a body, water being 1000, shows the weight of a cubic foot of that body in ounces avoirdupois. Then, if the magnitude of the body be known, its weight can be computed, or if its weight be known, its magnitude can be calculated, provided we know its specific gravity, or of the magnitude, weight, and specific gravity, any two being known, the third may be found.

To find the magnitude of a body from its weight: Say, as the specific gravity is to its weight in ounces, so is one cubic foot to its magnitude in feet.

To find the weight of a body from its magnitude: Say, as one cubic foot is to its magnitude in feet, so is its specific gravity to its weight in ounces.

THE WEIGHT OF DIFFERENT SUBSTANCES.

Name of Body.	Weight of a cubic foot		Weight of a cubic inch.		Number of cubic inches. in a lb.	Weight of a cubic yard in tons.
	In oz.	In lbs.	In oz.	In lbs.		
	1.	2.	3.	4.	5.	6
Platina	19500	1218.75	11.284	.7053	1.417	—
Copper, cast	8788	549.25	5.086	.3178	3.146	—
Copper, sheet	8915	557.18	5.159	.3225	3.103	—
Brass, cast	8396	524.75	4.852	.3037	3.293	—
Iron, cast	7271	454.43	4.203	.263	3.802	—
Iron, bar	7631	476.93	4.410	.276	3.623	—
Lead	11344	709.00	6.456	.4103	2.437	—
Steel, soft	7833	489.56	4.527	.2833	3.530	—
Steel, hard	7816	488.50	4.517	.2827	3.537	—
Zinc, cast	7190	449.37	4.156	.26	3.845	—
Tin, cast	7292	455.75	4.215	.2636	3.790	—
Bismuth	9880	619.50	5.710	.3585	2.789	—
Gun Metal	8784	549.00	5.0775	.3177	3.147	—
Sand	1520	95.00	.8787	.055	18.190	1.145
Coal	1250	78.12	.7225	.0452	22.120	0.941
Brick	2000	125.00	1.156	.0723	13.824	1.506
Stone, paving	2416	151.00	1.396	.0873	11.443	1.820
Stone, Bristol	2554	159.62	1.478	.0923	10.825	1.924
Grindstone	2143	133.94	1.240	.07751	12.901	1.614
Chalk, British	2781	173.81	1.609	.1005	9.941	2.095
Jet	1259	78.69	0.729	.04553	21.959	0.948
Salt	2130	133.12	1.233	.07704	12.980	1.604
Slate	2672	167.00	1.544	.0967	10.347	2.012
Marble	2742	171.37	1.585	.0991	10.083	2.065
White Lead	3160	197.50	1.826	.1143	8.750	—
Glass	2880	180.00	1.664	.1042	9.600	—
Tallow	945	59.06	.5462	.0342	29.258	—
Cork	240	15.00	.138	.0087	115.200	—
Larch	544	34.00	.315	.0197	50.823	—
Elm	556	34.75	.321	.0201	49.726	—
Pine, pitch	660	41.25	.382	.024	41.890	—
Beech	696	43.50	.403	.0252	39.724	—
Teak	745	46.56	.431	.027	37.113	—
Ash	760	47.50	.140	.0275	36.370	—
Mahogany	852	53.25	.493	.0308	32.449	—
Oak	970	60.62	.561	.0351	28.505	—
Oil of Turpentine	870	54.37	.503	.0315	31.771	—
Olive Oil	915	57.18	.529	.0331	30.220	—
Linseed Oil	932	58.25	.539	.0337	29.665	—
Spirits, proof	927	57.93	.536	.03352	29.288	—
Water, distilled	1000	62.50	.578	.03617	27.648	0.753
Water, sea	1028	64.25	.594	.0372	26.891	0.774
Tar	1015	63.43	.587	.0367	27.242	—
Vinegar	1026	64.12	.593	.037	26.949	—
Mercury (at 60°)	13568	848.00	7.851	.1908	2.037	—

The following practical rules, if retained in the memory, will frequently be found useful :

To find the weight of round bar iron—
Square the diameter in inches ; this, multiplied by the length in feet, and again by 2.6, will give the weight of the bar in pounds for wrought iron.

The rule for cast iron is—
Diameter squared $\times$ length in feet $\times$ 2.48 = weight in pounds.

Example : What is the weight of a wrought iron bar whose diameter is 3 inches, and length 5 feet ?
Solution : $3^2 \times 5 \times 2.6 = 117$ lbs.

WEIGHT AND MEASURE OF WATER AT THE COMMON TEMPERATURE.

1 pint = 34.65 cubic inches, or 1.25 lbs.
1 gal. = 277.274 cubic inches, or 10 lbs.
11.2 gals. = 1 cwt.
224 gals. = 1 ton.
1 cubic inch = 252.45 grs., or .03617 lbs.
12 " inches = .434 lbs.
1 " foot = 6.25 gals., or 1000 ozs., or 62.5 lbs.
1.8 " " = 1 cwt.
35.84 " " = 1 ton.
1 cylindrical inch = .02842 lbs.
12 " inches = .341 lbs.
1 " foot = 5 gals., or 49.1 lbs.
2.282 " feet = 1 cwt.
45.64 " " = 1 ton.
1 cubic inch of mercury = 3425.25 gr.

SPECIFIC GRAVITY OF GASES.

That of the Atmosphere being taken as 1.

Nitrous acid	2.638
Chlorine	2.500
Carbonic Acid	1.5277
Muriatic acid	1.284

SPECIFIC GRAVITY OF GASES (*Continued*).

Oxygen	1.111
Azote	0.9723
Carbureted hydrogen	0.9722
Ammonia	0.5902
Steam of Water	0.481
Hydrogen	.0694
Arseniacal gas	10.6
Mercurial do	6.976
Arseniacal acid	13.850
Anhydrous sulphuric acid	3.00
Selenitic sulphuric acid	4.03
Chloride of yellow sulphur	4.70
Chloride of red sulphur	3.70
Iodide of arsenic	16.10
Protochloride of mercury	8.35
Bichloride of do.	9.80
Protobromide of do.	10.14
Bi-bromide of do.	12.16
Bi-iodide of do.	15.6
Sulphate of do.	5.5
Bromide of cyanogen	3.61
Camphor	5.468
Spirits of turpentine	4.763
Benzoin	2.77
Napthaline	4.528
Sulphate of carbon, vapor of	2.644
Alcohol	1.6133
Ether	2.586
" acetic	3.067
" oxalic	5.087
" benzoic	5.409
Spirit of wood	1.120
Sulphate of methylene	4.565
Acetate of do.	2.563
Potato oil	3.147
Acetone	2.019
Acetic acid	2.77
Benzoic acid	4.27
Valeric acid	3.68
Cyanhydric acid	0.947
Cacodyle	7.1
Vapor of water	0.6235

SPECIFIC GRAVITY OF WATER AT DIFFERENT TEMPERATURES.

THAT AT 62° BEING TAKEN AS UNITY.

38° F.....	1.00115	50° F.....	1.00087	62° F.....	1.00000
40	1.00113	52	1.00076	64	.99980
42	1.00111	54	1.00064	66	.99958
44	1.00107	56	1.00050	68	.99936
46	1.00102	58	1.00035	70	.99913
48	1.00095				

THE SPECIFIC GRAVITY OF VARIOUS BUILDING MATERIALS.

THE SPECIFIC GRAVITY OF RAIN-WATER BEING 1000.

Woods.

Ash, dry.....	from	690	to	845
Beech.....	"	696	"	854
Birch	"	720		
Cedar, Indian.....	"	1315		
" of Libanus.....	"	486	"	603
Cherry	"	672	"	741
Chestnut	"	535	"	685
Cypress	"	644	"	655
Elm, seasoned.....	"	553	"	588
Fir, Norway Spruce.....	"	512		
" American.....	"	465		
Larch, Red, seasoned.....	"	496	"	640
" White	"	364		
Mahogany, Spanish.....	"	816	"	852
" Honduras	"	560		
Oak, Irish Bog.....	"	1046		
" American.....	"	752		
" English, dry.....	"	625		
Pine, American Pitch.....	"	741	"	936
Poplar.....	"	374	"	529
Sycamore.....	"	590	"	645
Teak, dry.....	"	657	"	832
Walnut, dry.....	"	616	"	735
Willow, dry.....	"	404	"	568

SPECIFIC GRAVITY OF MATERIALS (*Continued*).

Stones and Cements.

Basalt	from	2478	to	3000
Brick, common	"	1557	"	2000
" Welsh Fire	"	2408		
Brickwork	mean	1520		
Chalk	from	2315	"	2657
Flint	"	2580	"	2630
Granite	"	2624	"	3000
Marble	"	2580	"	2840
Mortar, hair, dry	"	1384		
" various, dry	"	1414	"	1393
Plaster, cast	"	1286		
Slate	"	2512	"	2888
Stone, Blue Lias Limestone	"	2467		
Stonework	"	2000	"	2686
Tile, common	"	1815	"	1858

Metals.

Brass, Cast	from	8100		
Copper, Cast	"	8607		
Iron, Bar	"	7600	to	7800
" Cast	"	7200	"	7600
Lead	"	11352	"	11407
Pewter	"	7248		
Platina	"	21531		
Steel	"	7780	"	7840
Tin	"	7291	"	7299

Earths, &c.

Clay, common	from	1919		
Coke	"	744		
Coal	"	1269	to	1526
Earth, common	"	1520	"	2016
Gravel	"	1749		
Lime, quick	"	843		
Marl	"	1600	"	2870
Sand, quartz	"	2750		
" common	"	1454	"	1886
Shingle	"	1424		
Water, rain	"	1000		
" sea	"	1027		

THE WEIGHT OF MATERIALS.

GASES, *at 32° Fahr., and under One Atmosphere.*

	Weight of a Cubic Foot in Lbs. Avoir.
Air	0.080728
Carbonic Acid	0.12344
Hydrogen	0.005592
Oxygen	0.089256
Nitrogen	0.078596
Steam (ideal)	0.05022
Ether Vapor (ideal)	0.2093
Bisulphuret-of-carbon Vapour (ideal)	0.2137
Olefiant Gas	0.0795

LIQUIDS, *at 32° Fahr. (except Water, which is taken at 39.1° Fahr.)*

	Weight of a Cubic Foot in Lbs. Avoir.
Water, pure, at 39.1°	62.425
" sea, ordinary	64.05
Alcohol, pure	49.38
" proof spirit	57.18
Ether	44.70
Mercury	848.75
Naptha	52.94
Oil, Linseed	58.68
" Olive	57.12
" Whale	57.62
" of Turpentine	54.31
Petroleum	54.81

THE WEIGHT OF ONE LINEAL FOOT OF WROUGHT IRON—FLAT.

Size.		Weight.	Size.		Weight.	Size.		Weight.
Ins.	In.	Lbs.	Ins.	In.	Lbs.	Ins.	In.	Lbs.
1	by ¼	0.85	1¾	by ½	2.96	2¼	by ¾	5.70
1¼	by ¼	1.06	2	by ½	3.38	2½	by ¾	6.33
1½	by ¼	1.27	2¼	by ½	3.80	2¾	by ¾	6.97
1¾	by ¼	1.48	2½	by ½	4.22	3	by ¾	7.60
2	by ¼	1.69	2¾	by ½	4.65	3¼	by ¾	8.24
2¼	by ¼	1.90	3	by ½	5.07	3½	by ¾	8.87
2½	by ¼	2.11	3¼	by ½	5.49	3¾	by ¾	9.51
2¾	by ¼	2.32	3½	by ½	5.92	4	by ¾	10.14
3	by ¼	2.53	3¾	by ½	6.33	4¼	by ¾	10.77
3¼	by ¼	2.75	4	by ½	6.76	4½	by ¾	11.41
3½	by ¼	2.96	4¼	by ½	7.18	4¾	by ¾	12.04
3¾	by ¼	3.17	4½	by ½	7.60	5	by ¾	12.67
4	by ¼	3.38	4¾	by ½	8.03	5¼	by ¾	13.31
4½	by ¼	3.59	5	by ½	8.45	5½	by ¾	13.94
4½	by ¼	3.80	5¼	by ½	8.87	5¾	by ¾	14.57
4¾	by ¼	4.01	5½	by ½	9.30	6	by ¾	15.21
5	by ¼	4.22	5¾	by ½	9.72			
5¼	by ¼	4.44	6	by ½	10.14			
5½	by ¼	4.65				1½	by 1	5.07
5¾	by ¼	4.86				2	by 1	6.76
6	by ¼	5.07	1	by ¾	2.53	3	by 1	10.14
			1¼	by ¾	3.17	4	by 1	13.52
1	by ½	1.69	1½	by ¾	3.80	5	by 1	16.90
1¼	by ½	2.11	1¾	by ¾	4.44	6	by 1	20.28
1½	by ½	2.53	2	by ¾	5.07	7	by 1	23.66

WEIGHT OF ROUND IRON PER LINEAL FOOT.

$\frac{1}{4}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.	$1\frac{1}{8}$ in.
.165	.373	.663	1.043	1.493	2.082	2.654	3.360
$1\frac{1}{4}$ in.	$1\frac{3}{8}$ in.	$1\frac{1}{2}$ in.	$1\frac{5}{8}$ in.	$1\frac{3}{4}$ in.	$1\frac{7}{8}$ in.	2 in.	$2\frac{1}{8}$ in.
4.172	5.019	5.972	7.010	8.128	9.333	10.616	11.988
$2\frac{1}{4}$ in.	$2\frac{3}{8}$ in.	$2\frac{1}{2}$ in.	$2\frac{5}{8}$ in.	$2\frac{3}{4}$ in.	$2\frac{7}{8}$ in.	3 in.	$3\frac{1}{8}$ in.
13.440	14.975	16.688	18.293	20.076	21.944	23.888	25.926
$3\frac{1}{4}$ in.	$3\frac{3}{8}$ in.	$3\frac{1}{2}$ in.	$3\frac{5}{8}$ in.	$3\frac{3}{4}$ in.	$3\frac{7}{8}$ in.	4 in.	$4\frac{1}{4}$ in.
28.040	30.240	32.512	34.886	37.332	39.864	42.464	47.952
$4\frac{1}{2}$ in.	$4\frac{5}{8}$ in.	$4\frac{3}{4}$ in.	$4\frac{7}{8}$ in.	5 in.	$5\frac{1}{4}$ in.	$5\frac{1}{2}$ in.	6 in.
53.760	56.788	59.900	63.094	66.752	73.172	80.304	95.552

WEIGHT OF SQUARE IRON PER LINEAL FOOT.

$\frac{1}{4}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.	$1\frac{1}{8}$ in.
.211	.475	.845	1.320	1.901	2.588	3.380	4.278
$1\frac{1}{4}$ in.	$1\frac{3}{8}$ in.	$1\frac{1}{2}$ in.	$1\frac{5}{8}$ in.	$1\frac{3}{4}$ in.	$1\frac{7}{8}$ in.	2 in.	$2\frac{1}{8}$ in.
5.280	6.390	7.604	8.926	10.352	11.883	13.520	15.263
$2\frac{1}{4}$ in.	$2\frac{3}{8}$ in.	$2\frac{1}{2}$ in.	$2\frac{5}{8}$ in.	$2\frac{3}{4}$ in.	$2\frac{7}{8}$ in.	3 in.	$3\frac{1}{8}$ in.
17.112	19.066	21.120	23.292	25.560	27.939	30.416	33.010
$3\frac{1}{4}$ in.	$3\frac{3}{8}$ in.	$3\frac{1}{2}$ in.	$3\frac{5}{8}$ in.	$3\frac{3}{4}$ in.	$3\frac{7}{8}$ in.	4 in.	$4\frac{1}{8}$ in.
35.704	38.503	41.408	44.418	47.534	50.756	54.084	57.517
$4\frac{1}{4}$ in.	$4\frac{3}{8}$ in	$4\frac{1}{2}$ in.	$4\frac{5}{8}$ in.	$4\frac{3}{4}$ in.	$4\frac{7}{8}$ in.	5 in.	$5\frac{1}{8}$ in.
61.055	64.700	68.448	72.305	76.264	80.333	84.480	88.784

WEIGHT OF ANGLE AND T IRON.

RULE FOR CALCULATING WEIGHT OF ORDINARY ANGLE AND T IRON.

W = Weight of angle-iron per lineal foot.
B = Breadths of flanges added in decimal parts of a foot.
T = Thickness of angle-iron in decimal parts of a foot.
w = Weight of iron in lbs. per sq. foot of the thickness of the angle-iron.

$$W = B - T \times w.$$

Weight of a Square Foot of Boiler Plate Iron, from $\frac{1}{8}$ to 1 inch thick, in lbs. avoirdupois.

$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.
5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40

IRON, SPLICES AND BOLTS REQUIRED FOR ONE MILE OF TRACK.

TONS OF IRON.

RULE.—To find the number of tons of rail to the mile, divide the weight per yard by 7, and multiply by 11, thus: for 56 pound rail, divide 56 by 7, equal 8, multiplied by 11 equal 88 tons, for one mile of single track.

Weight of Rail per Yard.	Tons per mile.	Weight of Rail per yard.	Tons per mile.
12 lbs.	18 tons 1920 lbs.	45 lbs.	70 tons 1600 lbs.
14 "	22 " "	48 "	75 " 960 "
16 "	25 " 320 "	50 "	78 " 1280 "
18 "	28 " 640 "	52 "	81 " 1600 "
20 "	31 " 960 "	56 "	88 " "
22 "	34 " 1280 "	57 "	89 " 1280 "
25 "	39 " 640 "	60 "	94 " 640 "
26 "	40 " 1920 "	62 "	97 " 960 "
27 "	42 " 960 "	64 "	100 " 1280 "
28 "	44 " "	65 "	102 " 320 "
30 "	47 " 320 "	68 "	106 " 1920 "
33 "	51 " 1920 "	70 "	110 "
35 "	55 " "	72 "	113 " 320 "
40 "	62 " 1920 "	76 "	119 " 960 "

SPLICES AND BOLTS FOR ONE MILE OF TRACK.

30	feet	of	Rail	requires	740	Splices;	1408	Bolts and Nuts.
28	"	"		754	"	1508	"	"
27	"	"		782	"	1564	"	"
25	"	"		844	"	1688	"	"
24	"	"		880	"	1760	"	"

WEIGHT OF ONE HUNDRED BOLTS OF THE ENUMERATED SIZES.

WITH SQUARE HEADS AND NUTS.

Lengths	¼ in.	5/16 in	⅜ in.	7/16 in	½ in.	⅝ in.	¾ in.	⅞ in.
1½ in.	4.16	7.59	10.62	15.94	23.87	39.31	.....	.....
1¾ "	4.22	7.87	11.72	16.90	25.06	41.48	.....	.....
2 "	4.75	8.56	12.38	18.25	26.44	45.69	73.62	.....
2¼ "	5.31	9.12	12.90	19.38	28.62	49.50	76.	.....
2½ "	5.97	9.59	14.69	20.69	29.50	51.25	79.75	.....
2¾ "	6.50	10.44	16.47	21.50	31.16	53.	83.	.....
3 "	.....	11.78	17.88	22.38	32.44	56.	85.38	127.25
3½ "	.....	11.81	18.94	26.19	39.75	63.12	93.44	140.56
4 "	.....	.....	20.59	28.87	42.50	74.87	108.12	148.37
4½ "	.....	.....	21.69	29.87	44.87	.79.62	113.12	158.76
5 "	.....	.....	23.62	32.31	48.81	83.	122.	167.25
5½ "	.....	.....	25.81	34.44	51.38	87.88	128.62	174.88
6 "	.....	.....	26.87	36.62	53.31	92.38	131.75	204.25
6½ "	.....	.....	.....	.....	56.87	96.88	139.56	214.69
7 "	.....	.....	.....	.....	59.12	99.87	145.50	228.44
7½ "	.....	.....	.....	.....	61.87	105.75	150.88	235.31
8 "	.....	.....	.....	.....	64.41	109.50	157.12	239.88
9 "	.....	.....	.....	.....	70.50	118.12	169.62	258.12
10 "	.....	.....	.....	.....	77.	128.13	184.	276.18
11 "	.....	.....	.....	.....	82.88	136.19	195.13	295.69
12 "	.....	....	.....	.....	86.37	144.87	209.75	311.94
13 "	.....	.....	.....	.....	92.	155.50	219.37	335.81
14 "	.....	.....	.....	.....	97.75	163.58	237.50	351.88
15 "	.....	.....	.....	.....	103.25	170.75	249.06	391.75

NUMBER OF NUTS OF THE ENUMERATED SIZES IN 100 POUNDS.

Wide.	Thick.	Hole.	Bolt.	Number of Square in 100 lbs.	Number of Hexagon in 100 lbs.
$\frac{1}{2}$	$\frac{1}{4}$	$\frac{13}{64}$	$\frac{1}{4}$	7540	8660
$\frac{19}{32}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	5000	6200
$\frac{11}{16}$	$\frac{3}{8}$	$\frac{19}{64}$	$\frac{3}{8}$	2320	3120
$\frac{25}{32}$	$\frac{7}{16}$	$\frac{11}{32}$	$\frac{7}{16}$	1940	2200
$\frac{7}{8}$	$\frac{1}{2}$	$\frac{25}{64}$	$\frac{1}{2}$	1180	1350
$\frac{31}{32}$	$\frac{9}{16}$	$\frac{29}{64}$	$\frac{9}{16}$	920	1000
$1\frac{1}{16}$	$\frac{5}{8}$	$\frac{33}{64}$	$\frac{5}{8}$	738	830
$1\frac{1}{4}$	$\frac{3}{4}$	$\frac{39}{64}$	$\frac{3}{4}$	420	488
$1\frac{7}{16}$	$\frac{7}{8}$	$\frac{45}{64}$	$\frac{7}{8}$	280	309
$1\frac{5}{8}$	1	$\frac{53}{64}$	1	180	216
$1\frac{13}{16}$	$1\frac{1}{8}$	$\frac{59}{64}$	$1\frac{1}{8}$	130	148
2	$1\frac{1}{4}$	$1\frac{1}{16}$	$1\frac{1}{4}$	96	111
$2\frac{3}{16}$	$1\frac{3}{8}$	$1\frac{5}{32}$	$1\frac{3}{8}$	70	85
$2\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{9}{32}$	$1\frac{1}{2}$	60	70
$2\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	34	40
$2\frac{15}{16}$	$1\frac{7}{8}$	$1\frac{5}{8}$	$1\frac{7}{8}$	30	37

SIZE, WEIGHT, LENGTH, AND STRENGTH OF IRON WIRE.

No. by Wire Gauge.	Diam. in decimals of 1 inch.	Feet to the lb.	Weight of 100 yards in lbs.	Weight of one mile in lbs.	Length of one bundle, 63 lb. in yards.
00000	.450	1.863	160.985	2845.34	39.12
0000	.400	2.358	127.208	2238.86	49.52
000	.360	2.911	103.043	1813.56	61.13
00	.330	3.465	86.583	1523.86	72.77
0	.305	4.057	73.958	1301.66	85.20
1	.285	4.645	64.583	1136.66	97.55
2	.265	5.374	55.829	982.59	112.85
3	.245	6.286	47.722	839.91	132.01
4	.225	7.454	40.248	708.36	156.53
5	.205	8.976	33.417	588.14	188.50
6	.190	10.453	28.699	505.10	219.51
7	.175	12.322	24.346	428.49	258.76
8	.160	14.736	20.358	358.30	309.46
9	.145	17.950	16.713	294.15	376.95
10	.130	22.333	13.433	236.42	468.99
11	.1175	27.340	10.973	193.12	574.14
12	.105	34.219	8.767	154.30	718.60
13	.0925	44.092	6.804	119.75	925.93
14	.080	58.916	5.092	89.62	1237.24
15	.070	76.984	3.897	68.59	1616.66
16	.061	101.488	2.956	52.03	2131.25
17	.0525	137.174	2.187	38.49	2880.65
18	.045	186.335	1.610	28.34	3913.04
19	.038	262.238	1.144	20.13	5506.99
20	.033	344.828	.870	15.31	7241.39

Weight of a Square Foot of Sheet Iron in lbs. avoirdupois.

No. 8.....	1	2	3	4	5	6	7	8
Pounds avoirdupois	12.5	12	11	10	8.74	8.12	7.5	6.86

No. 8.....	9	10	11	12	13	14	15	16
Pounds avoirdupois	6.24	5.62	5	4.38	4.31	3.12	3.95	2.50

No. 8.....	17	18	19	20	21	22
Pounds avoirdupois	2.5	1.86	1.93	1.54	1.5	1.25

SHRINKAGE OF CASTINGS.

Cast Iron	$\frac{1}{8}$ in.	per lineal ft.
Brass	$\frac{3}{16}$ "	"
Lead	$\frac{1}{8}$ "	"
Tin	$\frac{1}{12}$ "	"
Zinc	$\frac{5}{16}$ "	"

SIZES AND WEIGHTS OF WROUGHT IRON WELDED TUBES FOR GAS, STEAM AND WATER.

Inside Diameter.	Weight per Foot.	Inside Diameter.	Weight per Foot.
$\frac{1}{2}$ inch	.24	$2\frac{1}{2}$ inches.	5.77
$\frac{1}{4}$ "	.42	3 "	7.54
$\frac{3}{8}$ "	.56	$3\frac{1}{2}$ "	9.05
$\frac{1}{2}$ "	.85	4 "	10.72
$\frac{3}{4}$ "	1.12	$4\frac{1}{2}$ "	12.49
1 "	1.67	5 "	14.56
$1\frac{1}{4}$ "	2 25	6 "	18.77
$1\frac{1}{2}$ "	2.69	7 "	23.41
2 "	3.66	8 "	28.35

FORCE OF GRAVITY.

A body falling gains, in the first second of time, a velocity of 32 feet per second and falls a distance of 16 feet, 16 being the mean between 0, the velocity at the beginning, and 32 the velocity gained at the end of the first second.

The second second the body commences with a velocity of 32 feet, and under the constant force of gravity gains 32 feet more velocity, making 64 feet $= 4 \times 16$. It commences the third second with a velocity of 64 feet and gains 32 feet more, making 96 feet $= 6 \times 16$ feet. The mean between 32 feet, the velocity at the beginning of the second second, and 64 feet, the velocity at the close, is 48 feet $= 3 \times 16$ feet. The mean between 64 feet, the velocity at the beginning of the third second, and 96 feet, the velocity at the close, is 80 feet $= 5 \times 16$. Hence, the velocities are as the even numbers, and the distances as the odd numbers.

In any number of seconds, a body falls 16 feet $\times$ number of seconds, or

Let v be velocity of falling body.
" d " distance fallen through perpendicular in feet.
" t " time in seconds. Then

$$v = 32\ t,$$
$$d = 16\ t^2$$
$$v^2 = 64\ d,$$

or, putting these formula into words.

1. To find the depth of a shaft by letting a body fall down, when the time is known. Square the number of seconds it takes to fall; multiply them by 16 and the result is the depth in feet.

2. To learn how long it will take a body to fall down a shaft, when the depth is known, multiply the depth by 64, and take out the square root. The root is the velocity in seconds when it reaches the bottom, one-half of which is the mean velocity in feet per seconds, which, divided into the distance in feet, gives the time taken in falling.

Example :

The East mine shaft is 1600 feet deep. How long will it take a stone to fall down it, and what speed will it have attained when it strikes the bottom ?

Solution :

Depth of shaft, 1600 feet.

$$1{,}600 \times 64 = 102{,}400$$

$\sqrt{102{,}400} = 320$. $\frac{320}{2} = 160$ mean velocity in feet per second, and $\frac{1600}{160} = 10$ seconds to fall to bottom, and the speed per second when it strikes bottom will be 320 feet.

CHEMICAL MEMORANDA.

A SIMPLE or elementary substance is a body that cannot be resolved or separated into any simpler substances—as oxygen, carbon, iron.

A compound substance is one consisting of two or more constituents—as water, carbonic acid gas, olefiant gas.

The equivalent number or atomic weight expresses the relations that subsist between the different proportions by weight in which substances unite chemically with each other.

The equivalent of a compound is the sum of the equivalents of its constituents.

Specific gravity expresses the difference that subsists between the weights of equal volumes of bodies.

So far as chemists have been able to discover, there are about 65 elementary or simple substances.

No compound body contains all the elementary substances. Most compounds are composed of two, three, or four elements.

TABLE OF ELEMENTARY SUBSTANCES.

Names of Elements.	Symbol.	Atomic Weight.
Aluminium	Al	27.4
Antimony	Sb	122
Arsenic	As	75
Barium	Ba	137
Beryllium	Be	9.4
Bismuth	Bi	210
Boron	B	11
Bromine	Br	80
Cadmium	Cd	112
Calcium	Ca	40
Carbon	C	12
Cerium	Ce	92
Chlorine	Cl	35 5
Chromium	Cr	52.2
Cobalt	Co	58.8
Copper	Cu	63.4
Fluorine	F	19
Gold	Au	197

Names of Elements.	Symbol.	Atomic Weight.
Hydrogen	H	1
Indium	In	74
Iodine	I	127
Iridium	Ir	198
Iron	Fe	56
Lanthanum	Ln	93
Lead	Pb	207
Lithium	Li	7
Magnesium	Mg	24
Manganese	Mn	55
Mercury	Hg	200
Molybdenum	Mo	96
Nickel	Ni	58.8
Niobium	Nb	95
Nitrogen	N	14
Osmium	Os	199
Oxygen	O	16
Pallidium	Pd	106.6
Phosphorus	P	31
Platinum	Pt	197.4
Potassium	K	39.1
Rhodium	R	104
Rubidium	Rb	85
Ruthenium	Ru	104
Selenium	Se	79
Silicium or Silicon	Si	28
Silver	Ag	108
Sodium	Na	23
Strontium	Sr	87.6
Sulphur	S	32
Tantalum	Ta	182
Tellurium	Te	128
Thallium	Tl	204
Thorium	Th	231.5
Tin	Sn	118
Titanium	Ti	50
Tungsten	W	184
Uranium	U	120
Vanadium	V	51.2
Yttrium	Y	61.7
Zinc	Zn	65
Zirconium	Zr	89.6

LIST OF SOME BINARY COMPOUNDS.

Name of Compound.	Symbol.
Ammonia	$N\ H_3$
Bisulphide of Carbon	$C\ S_2$
Carbonic acid gas	$C\ O_2$
Carbonic oxide	$C\ O$
Cyanogen	$N\ C_2$
Hydrochloric acid	$H\ Cl$
Light carbureted hydrogen	$C\ H_4$
Nitric acid	$N\ O_5$
Olefiant gas	$C_2\ H_4$
Peroxide of iron	$Fe_2\ O_3$
Protoxide of iron	$Fe\ O$
Sulphurous acid gas	$S\ O_2$
Sulphuric acid	$H_2\ SO_4$
Sulphureted hydrogen	$H_2\ S$
Water	$H_2\ O$

NOMENCLATURE.

The compounds of the non-metallic elements with the metals and with each other have names ending in "ide" or "uret;" as Fe S, sulphide or sulphuret of iron.

When two or more equivalents of the non-metallic elements enter into combination, the number of equivalents is expressed by prefixes.

Bi	means	2 eq., as $N\ O_2$ binoxide of nitrogen.
Ter	"	3 eq., as $Sb_2\ S_3$ tersulphide of antimony.
Penta	"	5 eq.,
Sesqui	"	$1\frac{1}{2}$ eq., (= 2 to 3), as $Fe_2\ O_3$ sesquioxide of iron.
Proto	"	first, or 1 to 1, as Fe O protoxide of iron.
Sub	"	under, as $Cu_2\ O$ suboxide of copper.
Per	"	the highest, as $Cl\ O_4$ protoxide of chlorine.

Alkalies neutralize acids, forming salts.

The terminations "ic" and "ous" are used for acids, the former representing a higher state of oxidation than the latter.

When a substance forms more than two acid compounds, the prefixes "hypo," *under*, and "hyper," *above*, are used.

A base is a compound which will chemically combine with an acid.

A salt is a compound of an acid and a base.

When water is in combination with acids or bases, they are said to be hydrated.

COMMON NAMES OF CERTAIN CHEMICAL SUBSTANCES.

Aqua fortis	Nitric acid.
Bluestone, or blue vitriol	Sulphate of copper.
Calomel	Chloride of mercury.
Chloroform	Chloride of formyle.
Common salt	Chloride of sodium.
Copperas, or green vitriol	Sulphate of iron.
Corrosive sublimate	Bichloride of mercury.
Dry alum	Sulphate of alumina and potash.
Epsom salts	Sulphate of magnesia.
Ethiops mineral	Black sulphide of mercury.
Galena	Sulphide of lead.
Glauber's salts	Sulphate of soda.
Iron pyrites	Bisulphide of iron.
Jeweler's putty	Oxide of tin.
King's yellow	Sulphide of arsenic.
Laughing gas	Protoxide of nitrogen.
Lime	Oxide of Calcium.
Lunar caustic	Nitrate of silver.
Mosaic gold	Bisulphide of tin.
Nitre, or salt petre	Nitrate of potash.
Oil of vitriol	Sulphuric acid.
Realgar	Sulphide of arsenic.
Red lead	Oxide of lead.
Rust of iron	Oxide of Iron.
Soda	Oxide of sodium.
Spirit of Hartshorn	Ammonia.
Spirit of salt	Hydrochloric acid.
Stucco, or plaster of Paris	Sulphate of lime.
Sugar of lead	Acetate of lead.
Vermillion	Sulphide of mercury.
Vinegar	Acetic acid.
Volatile alkali	Ammonia.
Water	Oxide of hydrogen.
White Vitriol	Sulphate of zinc.

TABLE.

Showing the Number of Volumes of various Gases which 100 Volumes of Water, at 60° Fahr. and 30 inches Barometric Pressure, can absorb. (*Dr. Frankland.*)

Ammonia	7800 volumes.
Sulphurous acid	3300 "
Sulphureted hydrogen	253 "
Carbonic acid	100 "
Olefiant gas	12.5 "
Illuminating hydrocarbons	Not determined, but probably more soluble than olefiant gas.
Oxygen	3.7 volumes
Carbonic oxide	1.56 "
Nitrogen	1.56 "
Hydrogen	1.56 "
Light carbureted hydrogen	1.60 "

When water has been saturated with one gas and is exposed to the influence of a second, it usually allows a portion of the first to escape, whilst it absorbs an equivalent quantity of the second. In this way a small portion of a not easily soluble gas can expel a large volume of an easily soluble one.

USEFUL MEMORANDA.

Mean circumference of the earth	24,856 miles.
Diameter of the earth	7,921 "
Radius of the equator	20,921,180 feet.
Polar semi-axis	20,853,180 "
Length of geographical or nautical mile,	6075.66 "
Ratio of nautical to English mile	1.15068 to 1.
Length of pendulum at the equator	39.01326 inches.
Lenth of pendulum at New York	39.10153 "
Force of gravity at New York, feet per second	32.1594
Tropical year	365.242245 days.

Length of an arc =	No. of deg. $\times$ rad. $\times$ .01745.
Circumference of a circle,	Diam. $\times$ 3.1416.
Area of do	Diam.^{2} $\times$ .7854.
Diameter of do	Cir. $\times$ .31831.
Side of an equal square	Diam. $\times$ .8862.
Diameter of equal circle,	$\sqrt{}$Area $\times$ 1.12837.
Ellipse, area	T. axis $\times$ C. axis $\times$ .7854.
Sphere, surface	Diam.^{2} $\times$ 3.1416.
" solidity	Diam.^{3} $\times$ .5236.
Square feet	Circular inches $\times$ .00456.
" "	Square inches $\times$ .00695.
" yards	Square feet $\times$ .111.
Cubic feet	Cubic inches $\times$ .00058.
" yards	Cubic feet $\times$ .03704.
" "	Cylindrical feet $\times$ .02909.
English miles	Lineal feet $\times$ .00019, or lineal yards $\times$ .000568.
" acres	Square yards $\times$ .00026067.
Parabola, area	$\frac{2}{3}$ of base $\times$ height.
1 square foot	183.346 circular inches.
Cub. ins. in imperial gal.	277.274.
" foot	6.232 imperial gallons.
" inches $\times$ .028848...	pints.
" " $\times$ .014424...	quarts.
" " $\times$ .003606...	gallons.
" " $\times$ .0004508..	bushels.
" " $\times$ .00005635	quarters.
" " $\times$ .0005787..	cubic feet.
" " $\times$ .0000214..	" yards.
" " $\times$ .0163.....	French litres.
" " $\times$ .257.....	lbs. cast iron.
" " $\times$ .278.....	" wrought iron.

Cub. inches	× .491..... =	lbs. quicksilver.
" "	× .4112.....	" lead.
" "	× .2632.....	" tin.
" "	× .2597.....	" zinc.
" "	× .3201.....	" copper.
" "	× .3058.....	" brass.
Statute acres	× .4840....	square yards.
Square links	× .4356....	" feet.
" feet	× 2.3.....	" links.
Links	× .22.....	yards.
"	× .66.....	feet.
Feet	× 1.5.....	links.
Cubic feet	× 2.200.....	cylindrical inches.
Cylind. ins.	× .0004546...	cubic yards.
Imperial gallons	× .1604	" feet.
" "	× 4.543	French litres.
Cubic feet	× .779.....	bushels.
Bushels	× .0476.....	cubic yards.
"	× 1 284.....	" feet.
"	× 2218.2.....	" inches.
Statute miles	× .869.....	mean geographical miles.
Pounds avoir.	× 7000...	grains.
Grains	× .0001429.....	pounds avoirdupois.
Pounds avoir.	× .009....	cwts.
" "	× .00045.	tons.
Tons	× 2,240.....	pounds avoirdupois.
"	× .984.....	tonnes, French.
Pounds on the square inch	× 144.....	pounds on the square foot.
Pounds on the square foot	× .007.....	pounds on the square inch.
Miles per hour	× 1.467..	feet per second.
Feet per second	× .682..	miles per hour.
French metres	× 3.281..	English feet.
" litres	× .2201...	imperial gallons.
" hectolitre	× 2.7512	English bushels.
" grammes	× .002205	pound avoirdupois.
" kilogrammes	× 2.205	" "
Dia. of a sphere	× .806..	dimensions of equal cube.
" "	× .6667	length of equal cylinder.
One atmosphere...	.....	14.7 pounds on the sq. inch.
"	.....	2116 " " foot.
"	.....	29.922 inches of mercury.
"	.....	33.9 feet of water.

MEASURES OF LENGTH.

The U. S. standard yard is the same as the imperial yard of Great Britain. It is determined as follows :— The rod of a pendulum vibrating seconds of mean time in the latitude of London in a vacuum at the level of the sea is divided into 391,393 equal parts, and 360,000 of these parts are 36 inches or 1 standard yard.

An inch is one 500,500,000th part of the earth's polar axis.

Artificers sometimes divide the inch into lines or twelfths, but more commonly into binary divisions – half, quarter, eighth, sixteenth, and thirty-second.

Mechanical engineers divide the inch decimally—10ths, 100ths, 1000ths, &c.

Civil Engineers divide the foot decimally.

The hand is used for heights of horses and the girths of spars.

The fathom = 2 yards.

The league = 3 nautical miles.

The pace = 3 ft.

The geographical or nautical mile = 1.15th statute mile.

The geographical degree = 60 geographical or nautical miles.

The length of a degree of latitude varies, being 68.72 miles at the equator, 69.05 miles in middle latitudes, and 69.34 miles in the polar regions. A degree of longitude is greatest at the equator, where it is 69.16 miles, and it gradually decreases toward the poles, where it is 0.

TABLE OF MEASURES OF LENGTH.

Inches.	Hands.	Feet.	Yards.	Fathoms.	Chains.	Fur.	Mile.
1	—	—	—	—	—	—	—
4	1	—	—	—	—	—	—
12	3	1	—	—	—	—	—
36	9	3	1	—	—	—	—
72	18	6	2	1	—	—	—
792	198	66	22	11	1	—	—
7,920	1,980	660	220	110	10	1	—
63,360	15,840	5,280	1760	880	80	8	1

MEASURES OF AREA.

(Used in Engineering and Science.)

Sq. inch.		Sq. foot.		Sq. yard.		Sq. mile
1	.....	—	.....	—	.....	—
144	.....	1	.....	—	.....	—
1,296	.....	9	.....	1	.....	—
—		27,878,400		3,097,600	.....	1

Land Measure :

	Sq. yards.		Sq. feet.
Perch	$30\frac{1}{4}$	.....	$272\frac{3}{4}$
Rood (40 perches)	1,210	.....	10,890
Acre (4 roods, or 10 sq. chains)	4,840	.....	43,560

Used in the Arts :

Square (of roofing or flooring)	—	.....	100

MEASURES OF WEIGHT.

The U. S. Standard unit of weight is the Troy pound of the Mint which is the same as the imperial standard pound of Great Britain, and is determined as follows: A cubic inch of distilled water in a vacuum, weighed by brass weights also in a vacuum, at a temperature of 62° Fahrenheit's thermometer, is equal to 252.458 grains, of which the standard Troy pound contains 5760.

The U. S. Avoirdupois is determined from the standard Troy pound, and contains 700 Troy grains.

Avoirdupois Weight, Unit Equivalents.

Dr.		Oz.		Lbs.		Cwt.		T.
16	=	1	=	...		...		...
256	=	16	=	1		...		...
25,600	=	1,600	=	100	=	1		...
512,000	=	32,000	=	2000	=	20	=	1

Troy Weight, Unit Equivalents.

Gr.		Pwt.		Oz.		Lb.
24	=	1		...		...
480	=	20	=	1		...
5760	=	240	=	12	=	1

LONG TON TABLE.

Lbs.		Qr.		Cwt.		T.
28	=	1		...		...
112	=	4	=	1		...
2240	=	80	=	20	=	1

The gross ton is used in the United States in the Anthracite coal and the wholesale iron and plaster trades.

SOLID MEASURES.

	Cubic ins.	Cubic ft.
Cubic inch (subdivided decimally).....	1	...
1 foot × 1 inch × 1 inch	12	...
1 foot × 1 foot × 1 inch.....	144	...
Cubic foot (subdivided decimally or duodecimally)	1,728	1
Cubic yard.....	46,656	27
Load of hewn timber.....	...	50
Perch of masonry (= 16½ sq yds. face × 1½ ft. thick)	24¾ cubic ft.	
Cord of Wood.....	128 cubic ft.	

A cubic yard of earth is called a load.

In civil engineering the cubic yard is the unit to which estimates are reduced.

A pile 8 feet long, 4 feet wide and 4 feet high, contains 1 cord, and a cord foot is one foot in length of such a pile.

In measuring timber for shipment one-fifth of the solid contents of round timber is deducted for waste in hewing or sawing.

MEASURES OF CAPACITY.

The U. S. standard unit of liquid measure is the old English wine gallon, of 231 cubic inches, which is equal to 8.33888 pounds avoirdupois of distilled water at its maximum density; that is, at the temperature of 39.83° Fahrenheit, the barometer at 30 inches.

The U. S. Standard unit of dry measure is the British Winchester bushel, which is 18½ inches in diameter and 8 inches deep, and contains 2150.42 cubic inches, equal to 77.6274 pounds avoirdupois of distilled water, at its maximum density. A gallon dry measure, contains 268.8 cubic inches.

The British imperial standard gallon is a measure that will contain 10 pounds avoirdupois weight distilled water, weighed in air at 62° Fahrenheit, the barometer at 30 inches. It contains 277.274 cubic inches.

Gi.		Pt.		Qt.		Gal.		Bbl.		Hhd.
4	=	1		...		...		...		...
8	=	2	=	1		...		...		...
32	=	8	=	4	=	1		...		...
1008	=	252	=	126	=	$31\frac{1}{2}$	=	1		...
2016	=	504	=	252	=	63	=	2	=	1

The following denominations are also in use:

42 Gallons make 1 tierce.
2 Hhds. make 1 pipe or butt.
2 Pipes or 4 hhds. make 1 tun.

The denominations barrel and hogshead are used in estimating the capacity of cisterns, reservoirs, vats, &c. In Massachusetts, the barrel is 32 gallons.

The tierce, hogshead, pipe, butt and tun are the names of casks, and do not express any fixed measures. They are usually gauged, and have their capacity in gallons marked on them.

DRY MEASURE.

Pt.		Qt.		Pk.		Bu.
2	=	1		...		...
16	=	8	=	1		...
64	=	32	=	4	=	1

MEASURES OF VALUE.

United States Money.

The currency of the United States is decimal currency, and is sometimes called Federal money.

The unit is the dollar, and all the other denominations are either divisors or multiples of this unit.

Unit Equivalents.

Ml.		Ct.		D.		$		E.
10	=	1		...		...		...
100	=	10	=	1		...		...
1,000	=	100	=	10	=	1		...
10,000	=	1000	=	100	=	10	=	1

The character $ is supposed to be contraction of U. S. (United States), the U being placed upon the S.

The fineness of gold and silver coins means the proportion of the precious metals which they contain, and is generally expressed in thousandths of their total weight. The fineness of gold coins is also expressed in *carats*, or twenty-fourths of their total weight.

By act of Congress, January 18, 1837, all gold and silver coins must consist of 9 parts (.900) pure metal, and 1 part (.100) alloy. The alloy for gold must consist of equal parts of silver and copper, and the alloy for silver of pure copper.

The three-cent piece is 3 parts ($\frac{3}{4}$) silver, and 1 part ($\frac{1}{4}$) copper.

The nickel cent is 88 parts copper and 12 parts nickel.

The fineness of British gold coins is 22 carats, or $0.916\frac{2}{3}$; of British silver coins, 0.925, and of the coins of most other nations, 0.900.

The franc is the value of 4.5 grammes of pure silver, which, being alloyed with 0.5 grammes of copper, the full weight of the coin is 5 grammes. The fineness is 0.900. The Italian Lira is equal to the franc in weight, fineness, and value.

COMPARATIVE TABLE OF MONEYS.

English.	U. S.	French.	U. S.
1qr. =	\$ $.00\frac{1}{2}\frac{2}{4}\frac{1}{0}$	1 millime. =	\$ .000186
1d. =	$.02\frac{1}{6}\frac{}{0}$	1 centime. =	.00186
1s. =	.242	1 franc. =	.186
4s. 1d. $2\frac{4}{1}\frac{2}{2}\frac{}{1}$qr. =	1.00		
£1. =	4.84		

MEASURES OF VELOCITY.

Speed of turning, or angular velocity, is expressed in turns per second, per minute, or per hour, or in circular measure per second.

To convert turns into circular measure, multiply by 6.2832.

To convert circular measure into turns, multiply by 0.159155.

COMPARISON OF DIFFERENT MEASURES OF ANGULAR VELOCITY.

Circular measure per second.	Turns per second.	Turns per minute.	Turns per hour.
1	0.159155	9.5493	572.958
6.2832	1	60	3600
0.10472	0.016666	1	60
0.001745	0.000277	0.01666	1

MEASURES OF HEAVINESS

are expressed in units of weight per unit of volume ; as pounds to the cubic foot.

Specific gravity is the ratio of the heaviness of a given substance to the heaviness of pure water, at a standard temperature, which in the United States is 62° Fahr. To convert specific gravity, as estimated in the United States, into heaviness in lbs. to the cubic foot, multiply by 62.355.

MEASURES OF PRESSURE.

The intensity of pressure is expressed in units of weight on the unit of area, as pounds on the square inch ; or by the height of a column of some fluid ; or in *atmospheres*, the unit in this case being the average pressure of the atmosphere at the level of the sea. The following table gives a comparison of various units, in which the intensities of pressures are commonly expressed :

	Pounds on the square foot.	Pounds on the square inch.
One pound on the sq. in.....	144	1
One pound on the sq. foot.....	1	$0\frac{1}{144}$
One in. of mercury (that is weight of a column of mercury at 32° Fahr., one in. high).....	70.7275	0.491163
One foot of water (at 39.1° Fahr.).....	62.425	0.4335
One in. of water.....	5.2021	0.036125
One atmosphere, of 29.922 in. of mercury, or 760 millimetres.....	2116.3	14.7
One foot of air at 32° Fahr., and under the pressure of one atmosphere.....	0.080728	0.0005606

Comparison of Heads of Water in Feet with Pressures in Various Units.

One ft. of water at 52.53° Fahr. =	62.4	lbs. on the sq. ft.
" "	0.4333	lb. on the sq. in.
" "	0.0295	atmosphere.
" "	0.8823	in. of merc. at 32°
" "	773.	ft. of air at 32°, and one atmosphere.
On lb. on the sq. ft.	0.016026	ft. of water at 52.3° F.
" " in.	2.308	ft. of water.
One atmosphere of 29.922 in. of mercury	33.9	
One in. of mercury at 32°	1.1334	" "
One ft. of air at 32°, and one atmosphere	0.001294	"
One ft. of average sea water	1.026	ft. of pure water.

MEASURES OF WORK

are expressed in units of weight lifted through a unit of height; as in lbs. lifted one foot, called *foot-pounds*.

MEASURES OF POWER

are expressed in units of work done in a unit of time; as in foot-pounds per second, per minute, or per hour; or in conventional units called *horse-powers*.

One *horse-power*, United States measure, = 550 foot-pounds per second = 33,000 foot-pounds per minute = 1,980,000 foot-pounds per hour.

THE STATICAL MOMENT

of a given weight, relatively to a given vertical plane, is the product of the weight into its horizontal distance from that plane, and is expressed in the same sort of units with work.

Comparison of Measures of Statical Moment.

Inch-lb.					
12	1 ft-lb.				
112	$9\frac{1}{3}$ =	1 inch-cwt.			
1,344	112	12 = 1	foot-cwt.		
2,240	$186\frac{2}{3}$	20	$1\frac{2}{3}$ = 1	inch-ton.	
26,880	2240	240	20	12 = 1	foot-ton.

ABSOLUTE UNITS OF FORCE.

The "absolute unit of force" is a term used to denote the force which, acting on a unit of mass for a unit of time, produces a unit of velocity.

The unit of time employed is always a second.

The unit of velocity is one foot per second.

The unit of mass is the mass of so much matter as weighs one unit of weight near the level of the sea, and in some definite latitude.

The unit of weight chosen is, sometimes a grain, sometimes a pound avoirdupois ; and it is equal to 32.187 of the corresponding absolute units of force.

The proportions borne to each other by the absolute units of force in different countries are nearly the same as those of the units of work, and would be exactly the same but for the variation of the force of gravity in the latitude.

LIGHT.

Velocity of light, 192,000 miles per second, nearly.

Decomposition of Light.

Violet = maximum chemical ray.
Indigo.
Blue.
Green.
Yellow = maximum light ray.
Orange.
Red = maximum heat ray.

COMBINATIONS OF COLOR.

Primaries		Secondary.
Red and Yellow	form	Orange.
Red and Blue	"	Purple.
Yellow and Blue	"	Green.

Secondaries.		Tertiary.
Orange and Purple	form	Brown.
Orange and Green	"	Grey.
Purple and Green	"	Broken Green

CONTRASTS OF COLOR.

Primary colors.	Secondary in contrast to primary.	Tertiary in contrast to secondary.
Red	Green	Brown.
Yellow	Purple	Grey.
Blue	Orange	Broken Green.

SOUND.

Velocity in	Ft. per second.	Velocity in	Ft. per second.
Air	1,142	Copper	10,378
Water	4,900	Wood	12,000 to 16,000
Iron	17,500		

Distant sounds may be heard on a still day :—

Human voice	150 yds.	Military band	5,200 yds.
Rifle	5,300 "	Cannon	35,000 "

TO MEASURE DISTANCES BY SOUND.

RULE : Multiply the time the sound takes in seconds by 1142 ; the product will be the distance in feet.

NOTE.—Sound in common air moves uniformly at the rate of about 1,142 feet in a second. Cold and uneven surfaces retard its motion a little, and heat accelerates it in a small degree.

EXAMPLE 1 : I observed the flash of a gun 30 seconds before I heard the report. How far was it distant from me?

Answer.—$30 \times 1{,}142 = 34{,}260$ ft.

EXAMPLE 2 : I observed a flash of lightning, and after 6 strokes of my pulse I heard the thunder, and my pulse makes 68 strokes in a minute. How far was the thunder distant from me?

Answer.—1 mile 255.3 yards.

MISCELLANEOUS ARTICLES.

Barrel of tar	26¼ gallons.
Cable's length	240 yards
Cask of black lead	11½ cwt.
English Chaldron of coal	25½ "
" " coke	12½ to 15 cwt.
Chaldron of coal, heaped measure	36 bushels.
Cord of wood	128 cubic feet.
Dozen	12 articles.
Fagot of steel	120 lbs.
Fodder of lead	19½ cwt.
Gross	12 dozen
Great gross	12 gross
Bushel of wheat	60 pounds.
" " indian corn	56 "
" " oats	32 "
" " rye	56 "
" " wheat bran	20 "
Firkin of butter	56 "
Quintal of dry salt fish	100 "
Cask of raisins	100 "
Barrel of flour	196 "
Barrel of beef, pork or fish	200 "
Pig of ballast	56 "
Quire of paper	24 sheets
Ream of paper	20 quires or 480 sheets.
Bundle	2 reams.
Bale	5 bundles.
Roll of parchment	60 skins
Score	20 articles.

Sheet of paper folded into—

2	leaves is termed	folio size.
4	" "	4to. or quarto.
8	" "	8vo. or octavo.
12	" "	12mo. or duodecimo.
16	" "	16mo.
18	" "	18mo.
24	" "	24mo.
48	" "	48mo.

THE FEEDING PROPERTIES OF DIFFERENT VEGETABLES,
In comparision with 10 lbs. of hay.

Hay	10
Clover hay	8
Vetch hay	4
Wheat straw	52
Barley straw	52
Oat straw	55
Pea straw	6
Potatoes	28
Old potatoes	40
Turnips	60
Carrots	35
Cabbage	30 to 40
Peas and beans	2 to 3
Wheat	5
Barley	6
Oats	5
Rye	5
Indian corn	6
Bran	5
Oil-cake	2

Thus 2 lbs. of oil-cake is worth as much as 55 lbs. of oat straw.

In Kentucky, 80 pounds of bituminous or cannel coal make a bushel.

In Illinois, 80 pounds of bituminous coal make a bushel.

In Missouri 80 lbs. bituminous coal make a bushel.

In Indiana, 70 pounds of bituminous coal make a bushel.

In Pennsylvania, 76 pounds of bituminous coal make a bushel.

Coal, corn in the ear, fruit and roots are sold by heaped measure, that is, the bushel is heaped in the form of a cone, which cone must be 19½ inches in diameter (equal to the outside diameter of the standard bushel measure), and at least 6 inches in height.

Grain and some other commodities are sold by stricken measure, that is, the measure is to be stricken with a round stick or roller, straight and of the same diameter from end to end.

Glazing and stone-cutting are estimated by the square feet.

Painting, plastering, paving, ceiling, and paper-hanging are estimated by the square yard.

In estimating the paintings of mouldings, cornices, &c., the measuring line is carried into all the mouldings and cornices.

Flooring, partitioning, roofing, slating and tiling are estimated by the square of 100 square feet.

A thousand shingles are estimated to cover 1 square, being laid 5 inches to the weather.

A span is the distance that can be reached between the end of the middle finger and the end of the thumb. Among sailors, 8 spans are equal to 1 thumb.

A geographic mile is $\frac{1}{21600}$ of the distance around the centre of the earth.

A square mile of land is called a section.

A Gunter's chain used by land surveyors is 4 rods or 66 feet long, and consists of 100 links. 7.92 inches make a link.

Canal and railroad engineers use an engineer's chain, which consists of 100 links, each 1 foot long.

TABLE OF COLORS.

Used in Architectural and Mechanical Drawing.

Work.	Color.
Brickwork in plan or section...	Carmine, or crimson lake.
" in elevation.....	Venetian red.
" to be removed by alterations, flintwork or lead	Prussian blue.
Concrete works, stone.....	Sepia.
Clay, earth.....	Burnt umber.
Granite	Purple madder.
Timber (oak excepted).....	Raw sienna.
Oak, teak	Burnt sienna.
Fir, and most other timber....	Indian yellow.
Mahogany.....	Indian red.
Cast iron, and wrought iron in the rough.....	Payne's grey.
Wrought iron, bright.....	Indigo.
Steel, Bright	Indigo, with a little lake.
Brass	Gamboge.
Gun-metal.....	Dark cadmium.
Meadow land.....	Hooker's green.
Sky effects	Cobalt blue.

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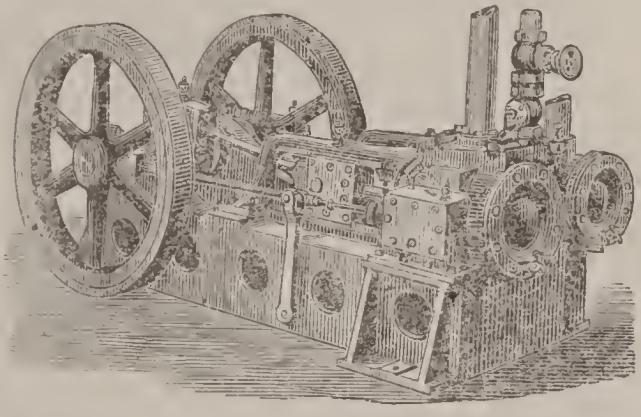

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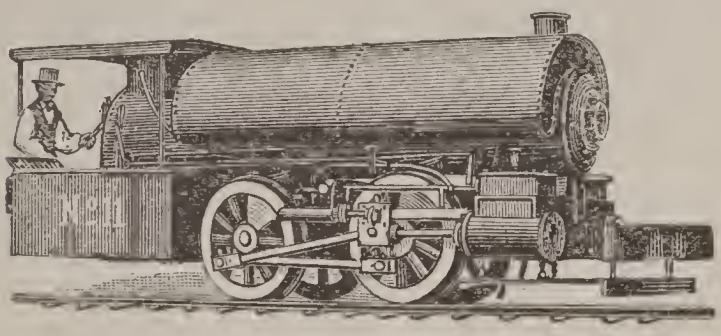

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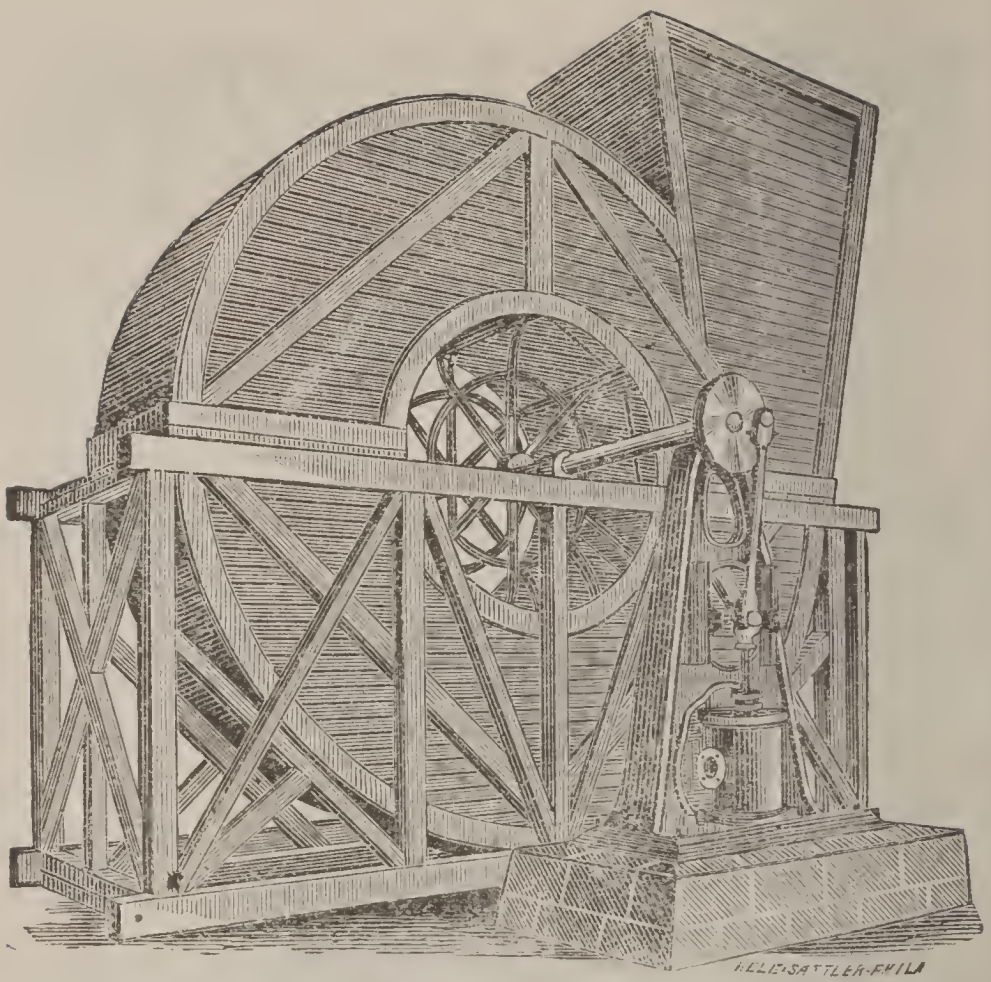

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Improved Balance Slide Valve,

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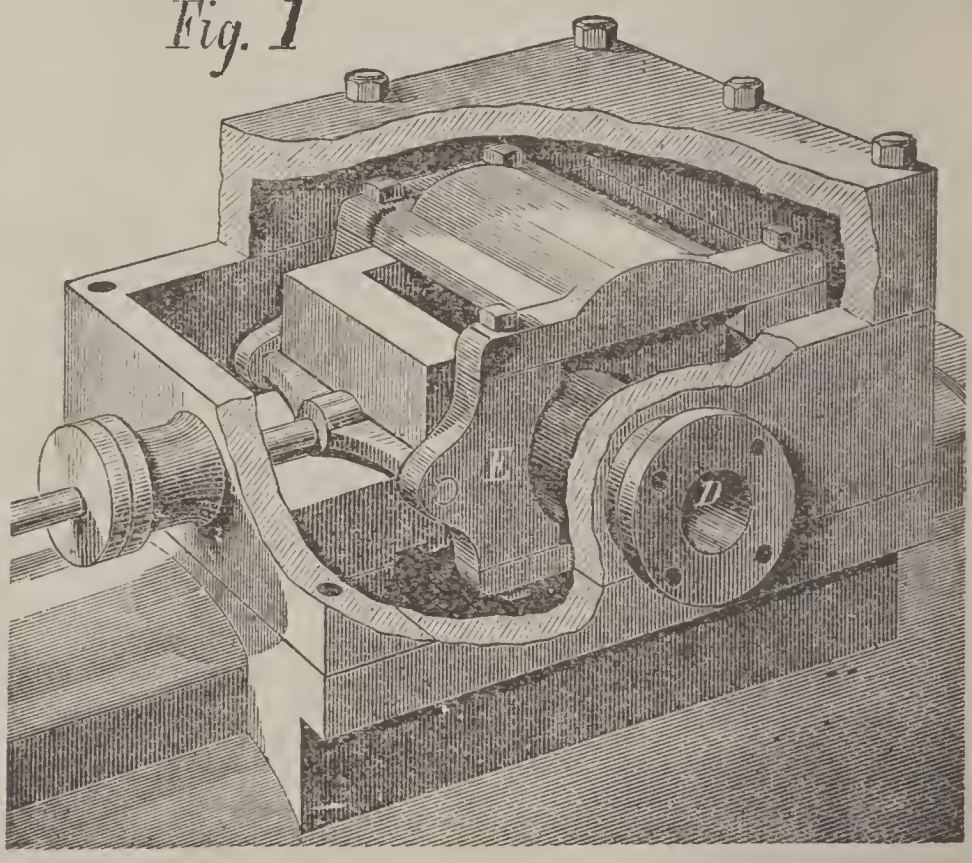
Fig. 1



We illustrate herewith an improved balance slide valve, formed of two valves working on opposite sides of the steam ports. These are held in place by bolts and springs, and are balanced through the equal pressure of steam on all sides. The principal advantages are that there is a very slight pressure of the valves on their seats, and that through there being double steam and exhaust ports, the steam acts more promptly on the piston, and is exhausted more rapidly with less back pressure.

A perspective view, with the chest broken away to show the valve, is given in Fig. 1. Fig. 2 is a vertical section, and Fig. 3 a plain view, the cover being removed. The steam ports A lead into the passages B, Fig. 2, at each end of the cylinder; each passage, therefore, has a double port. The exhaust ports C lead into a common exhaust D. The two slide valves are constructed in the usual manner, and

are connected by bolts as exhibited in Fig. 1, said bolts passing through projections on the valves and supports E. Upon each bolt is a spring to permit the valves to open and discharge condensed water from the cylinder, thus preventing the bursting of the latter. As shown in Fig. 2, steam is entering on the right hand side.

Fig. 2

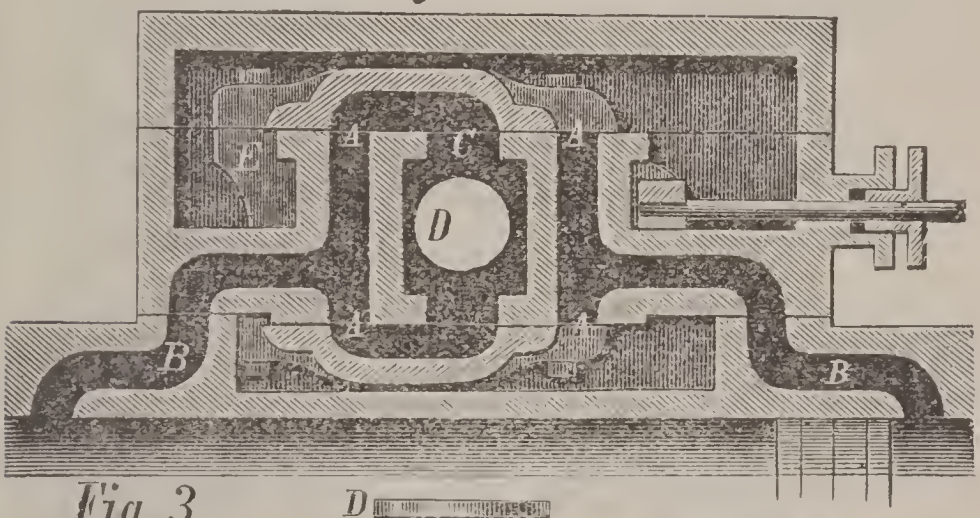
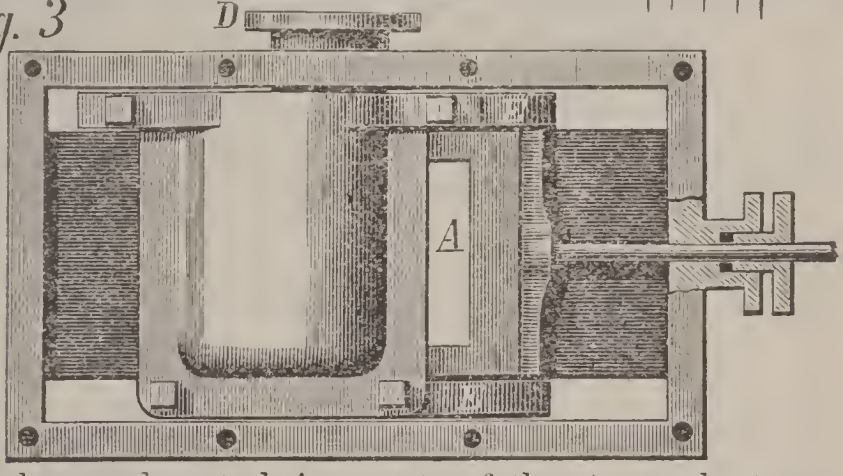


Fig. 3



The valves and ports being parts of the steam chest, are easily detached, and thus may be readily and economically repaired. It is especially adapted to locomotive or hoisting engines, which require frequent reversing, as the engineer can control his machine without shutting off steam.

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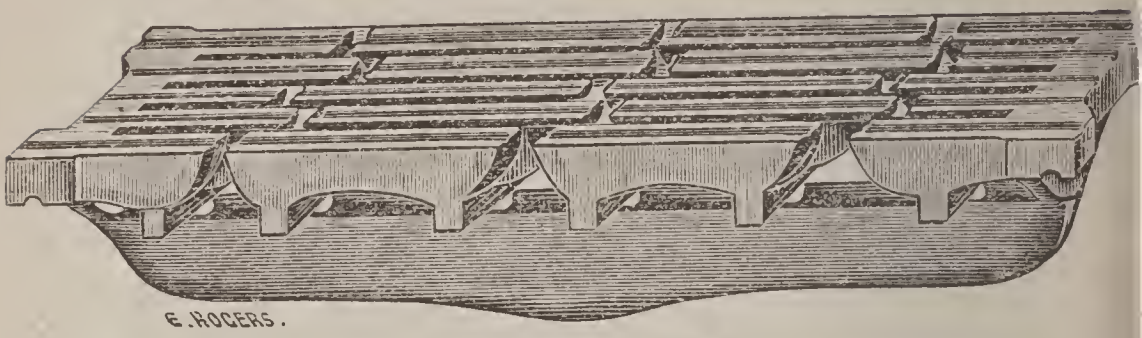

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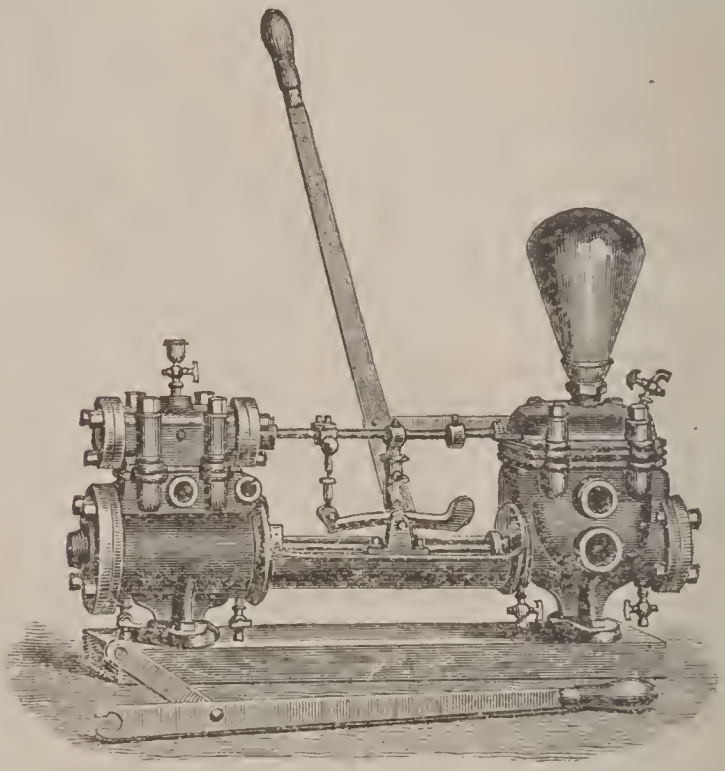

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